Global Goals Mapping: The Environment-human Landscape

A contribution towards the Natural Environment Research Council, The Rockefeller Foundation and Economic and Social Research Council initiative, Towards a Sustainable Earth: Environment-human Systems and the UN Global Goals

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As part of the Towards a Sustainable Earth: Environment-human Systems and the UN Global Goals initiative, the UK Natural Environment Research Council (NERC), The Rockefeller Foundation (RF) and the UK Economic and Social Research Council (ESRC) have combined forces to work towards the ambitious goal aim of identifying the urgent research priorities and innovation challenges that may inform and catalyse a paradigm shift in the global approach to sustainable development. The initiative is convening a high-level meeting at The Rockefeller Foundation Bellagio Center, Italy, 7-11 November 2016. This report, *Global Goals Mapping: The Environment-human Landscape*, has been commissioned by NERC to provide background material for the Bellagio meeting. It has been produced by the Sussex Sustainability Research Programme, University of Sussex, Brighton, UK (SSRP), and the UN Environment World Conservation Monitoring Centre, Cambridge, UK (UNEP-WCMC). These organisations were tasked with synthesising research evidence, innovations and policies relating to the environment-human interactions that apply across the 17 UN Global Goals on Sustainable Development. It also analysed the relationships between all 17 Global Goals with respect to environment-human interactions.

The SSRP was established in 2015 by the University of Sussex in collaboration with the Institute of Development Studies (IDS). It aims to support the sustainability of life on Earth through rigorous interdisciplinary research that informs policy and stimulates action.

UNEP-WCMC, the specialist biodiversity centre of UN Environment, is a collaboration between UN Environment and WCMC, a UK non-profit organisation. Working with partners worldwide, UNEP-WCMC collates, manages, analyses and synthesises data on biodiversity and ecosystem services to inform decision making.

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Summary

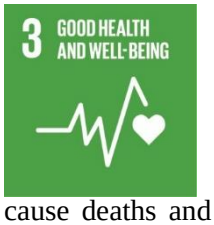
The UK Natural Environment Research Council (NERC), The Rockefeller Foundation (RF), and the UK Economic and Social Research Council (ESRC) recognise that the development challenges of the 21st century require both a shift in thinking and actions that prepare us for the future, while enabling more effective development interventions today. These organisations are establishing a new initiative: 'Towards a Sustainable Earth: Environment-human Systems and the UN Global Goals' (TaSE) as part of their commitment to seeing the 17 Sustainable Development Goals (also known as Global Goals) become a reality. The core premise of the TaSE initiative is that environment-human interactions must be central to all development.

The TaSE initiative is convening a meeting at The Rockefeller Foundation Bellagio Centre (7-11 November 2016) to identify the major research and innovation questions relevant to the achievement of the overarching ambition of this initiative. To help focus discussions during this meeting, NERC commissioned the Sussex Sustainability Research Programme (SSRP) at the University of Sussex and the UN Environment World Conservation Monitoring Centre (UNEP-WCMC) to produce a "synthesis of past and current research and innovation relating to the policy landscape surrounding the environment-human relationships and systems that interact across the UN Global Goals".

The commissioned work is encapsulated in this report, *Global Goals mapping: the environment-human landscape.* For each Goal, the first part of this report summarises the role of environment-human interactions and synthesises relevant research evidence, key innovations and policies, and knowledge and research gaps.

Global Goal 1 calls for an end to poverty in all its forms everywhere. The environment and services it provides support a range of livelihoods and can help prevent poverty. Environmental degradation can adversely affect the poor, who rely heavily on natural resources. Poverty can also make sustainable environmental management more difficult (Global Goal 15). Ensuring rights to land and natural resources is essential for poverty alleviation. Natural disasters (including climate-related extreme events, Global Goal 13) can exacerbate poverty, although effective environmental management can help reduce disaster risk. **Knowledge and research gaps relate to: the relationships between environmental services, biodiversity and poverty alleviation (such as analyses of non-income dimensions of poverty along with income and assets); the role of ecosystems in reducing impacts of natural disasters (such as links between vegetation and flooding).**

Global Goal 2 calls for an end to hunger, for food security and improved nutrition and promotion of sustainable agriculture. All food is ultimately derived from the environment. Sustainable management and use of the environment (Global Goal 12, 14 and 15) are key to ending hunger, malnutrition and food insecurity. Poor diets constitute the number-one driver of disease globally (Global Goal 3). Increasing incomes, changing diets and urbanisation will increase demand for land and wild food species, water pollution from fertilizer use and livestock production, and soil degradation. Achieving this Goal will depend on both reducing demand (for instance, through healthier diets and decreasing waste) and increasing supply. **Knowledge and research gaps relate to: management and governance (such as subsidies for fertilisers and pesticides, reducing food loss and waste); food provisioning and biodiversity (such as impacts of pesticides on pollinators; exploitation and trade of wild meat); nutrition and food security (such as data and metrics for diet quality and food systems).**



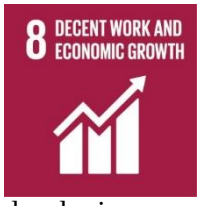
Global Goal 3 calls for healthy lives and well-being for all. The environment provides numerous health benefits, including food (Global Goal 2) and improvements to mental health through interaction with nature. However, it is a reservoir for pathogens and parasites, so environmental management (Global Goals 14 & 15) is essential for disease management. Exposure to pollution and contamination influences non-communicable diseases. Environmental change and natural disasters can directly cause deaths and diseases and indirectly impact health. **Knowledge and research gaps relate to: infections and parasitic diseases and the environment (such as innovations to control neglected tropical diseases and disease vectors); mental health and well-being (such as the mechanisms by which exposure to nature affects mental health outcomes); and health implications of environmental change (such as evaluating health benefits of climate change adaptation).**

Global Goal 4 calls for inclusive and equitable quality education and lifelong learning opportunities for all. Education plays a large role in shaping how we behave towards the environment. It can increase environmental awareness and concern, and help to change behaviour and improve management of natural resources. Awareness of the role of education in sustainable development has been increasing. **Knowledge and research gaps relate to: evidence base for best practice (such as on the links between raising awareness and behaviour changes); understanding teaching and learning; early childhood education; and mechanisms of networking and partnership in education for sustainable development.**

Global Goal 5 calls for gender equality. Environmental change affects women and men in different ways, and women play important roles in environmental management. Rights to land, natural resources and biodiversity (Global Goals 14 and 15), as well as access to food, energy, water and sanitation (Global Goals 2, 6 and 7) are essential for achieving gender equality, whereas climate change (Global Goal 13) can amplify existing gender inequalities. **Knowledge and research gaps relate to: sex-disaggregated information and gender statistics; gender-sensitive environmental assessments; case studies and syntheses of less-researched issues (such as gender-environment relations in urban settings); and long term monitoring data.**

Global Goal 6 calls for available and sustainable management of water and sanitation for all. Water links humans and the environment, and sustains human life. Adequate and equitable management of this natural resource will become more important with climate change (Global Goal 13). Access to sanitation reduces environmental pollution (including water-borne pathogens) and its health impacts (Global Goal 3). Pollutants affecting water quality occur as a result of agriculture (Global Goal 2), industry (Global Goals 9 and 12), energy production and extractive processes (Global Goal 7). Water-use efficiency across all sectors can be supported by integrated water-use management. Water-related ecosystems need to be conserved to retain ecosystem services and biodiversity. **Knowledge and research gaps relate to: management and governance (such as guidelines for siting, designing and optimising dams); water treatment (such as development of advanced technologies); water demand; and freshwater biodiversity.**

Global Goal 7 calls for access to affordable, reliable, sustainable and modern energy for all. All power generation derives from, and impacts the environment. Fossil fuel use is the main source of greenhouse gases (Global Goal 13) and has other environmental impacts. A move to sustainable energy requires shifting to renewables such as hydropower, marine, solar and wind, and bioenergy, all with differing environmental impacts. Improving the environmental sustainability of energy production requires addressing its impacts, including on climate change, developing technologies for waste-to-energy conversion and carbon capture and storage, and increasing energy efficiency (Global Goals 8 and 12)**. Knowledge and research gaps relate to: energy infrastructure and investment; non-renewable energy sources (such as the impact of deep-water drilling); and renewable energy sources (such as the combined effects of energy facilities on particular species).**



Global Goal 8 calls for sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all. Decoupling economic growth from environmental degradation and increasing resource efficiency are key to achieving this Goal. Green growth and a green economy are about shifting to a model where well-being is at the centre of development and natural assets are maintained (Global Goals 14 and 15). Transitioning to a green economy can be supported by developing new indicators of sustainable economic growth, reforming finance, removing perverse subsidies, and developing green jobs and sustainable tourism. **Knowledge and research gaps relate to: green growth and resource decoupling (including measuring resource efficiency); and green economy transitions and decision-making processes.**

Global Goal 9 calls for resilient infrastructure, inclusive and sustainable industrialisation, and innovation. Infrastructure and green infrastructure are both key to development. All infrastructure impacts the environment and needs be resilient to environmental change and hazards. Industrial activity currently causes large negative environmental impacts; reducing these requires increasing resource efficiency in, and reducing pollution from production (Global Goals 8 & 12). **Knowledge and research gaps relate to: infrastructure (such as transparency and analysis of**

carbon footprints across the ICT industry); and industrialisation (such as how to avoid double-counting industrial greenhouse gas emissions).

Global Goal 10 calls for a reduction in inequality within and among countries. Unequal access to resources from the environment (Global Goals 14 and 15) affects livelihoods (Global Goal 1), food (Global Goal 2), water (Global Goal 6) and health (Global Goal 3). Inequality can also impact the environment. Environmental justice, the fair treatment and meaningful involvement of all people with respect to development, implementation and enforcement of environmental laws, regulations, and policies, is important for addressing inequality. Equitable sharing of genetic resources (Global Goal 15) is a specific environmental equality issue that has had greater attention in recent years. **Knowledge and research gaps relate to: environmental justice (such as environmental justice implications of climate change impacts and proposed solutions); and economic inequality and environmental conditions (such as mechanisms linking economic inequality and environmental conditions).**

Global Goal 11 calls for inclusive, safe, resilient and sustainable cities. Management of natural resources such as water (Global Goal 6) is key to developing sustainable cities, as is the management of environmental impacts of cities (such as municipal solid waste and urban expansion). Access to green spaces can make cities more liveable and attractive. Transforming natural land surfaces into impervious surfaces as part of urbanization, can make cities more prone to water-related disasters. Managing natural hazards can increase urban resilience. **Knowledge and research gaps relate to: environmental impact of urbanization (for example on aquifers); sustainable transport (including climate change mitigation in the transport sector); sustainable urbanisation (such as socio-technical capability for shaping resource flows); and access to green spaces.**

Global Goal 12 calls for sustainable consumption and production patterns. Making consumption and production sustainable includes minimising impacts on the environment and is closely linked to decoupling economic growth and environmental degradation (Global Goal 8). Different approaches are needed to increase the sustainability of production across sectors, including food (Global Goal 2), water (Global Goal 6), energy (Global Goal 7), tourism and mining. Action to achieve sustainable production and consumption includes taxes, subsidies, communications campaigns, public procurement policies, and standards. **Knowledge and research gaps relate to: current levels of production and consumption; innovation and policy impacts (such as factors determining the success of sustainable consumption and production policies).**

Global Goal 13 calls for action to combat climate change and its impacts. The climate is changing and continued emissions of greenhouse gases will cause further changes that pose risks to natural and human systems. Additional mitigation and adaptation efforts, and multiple approaches, are needed to reduce these risks. **Knowledge and research relate to: understanding climate change impacts (including within complex systems); potential mitigation and adaptation responses and their effectiveness (such as impacts, costs, and environmental side effects of carbon capture and storage; unintended impacts, trade-offs and synergies between policies).**

Global Goal 14 calls for the conservation and sustainable use of the oceans, seas and marine resources for sustainable development. Oceans provide a broad range of services to society. Exploitation of living marine resources has exceeded sustainable levels in many regions; ending overfishing could result in an increase in catches. Many other sectors, such as coastal development, tourism, shipping, seafloor mining, and marine renewable energies, also depend on oceans. Industrial and agricultural production are increasing inputs of harmful chemicals and nutrients into the oceans. Ocean acidification caused by increasing carbon dioxide in the atmosphere is of particular concern. Methods for the protection of coastal and marine ecosystems include marine protected areas, restoration schemes, and regulating exploitation. Recovery of depleted marine species and ecosystems is possible, but has so far been insufficient. **Knowledge and research gaps relate to: protection, restoration and management (such as local information for use in coastal zone management); fisheries (such as interactions between large-scale and small-scale fisheries); other uses of the oceans (such as how shipping routes and operations affect the marine environment); waste and pollution (such as the origin, fate and effects of microplastics and nanoparticles); and ocean characteristics (such as acidification and sea level rise)**.

Global Goal 15 calls for the protection, restoration and sustainable use of terrestrial ecosystems, sustainable management of forests, combating desertification, and halting and reversing land degradation and biodiversity loss. Environment-human interactions are central to achieving this Goal. Biodiversity and ecosystem services support livelihoods (Global Goal 1), and underpin production of food (Global Goal 2) and medicines (Global Goal 3), and water supply (Global Goal 6). The relationship between biodiversity, ecosystem functioning and ecosystem services is complex and not fully understood. However, there is clear evidence of the central role of biodiversity in the delivery of some ecosystem services. Efforts are increasing to integrate ecosystems and biodiversity into policy, strategies and practices across sectors. **Knowledge and research gaps relate to: extent and condition of terrestrial ecosystems and biodiversity (such as trends in agriculturally-important genetic resources and species experiencing recent rapid declines); value and role of terrestrial ecosystems and biodiversity (through integrated approaches such as spatially-explicit modelling and valuing changes in ecosystem services); and management and governance (such as effectiveness of environmental policies).**

Global Goal 16 calls for peaceful and inclusive societies, access to justice, and effective, accountable and inclusive institutions. Competition for renewable resources and environmental degradation can cause conflict and war, whereas natural resource management can support peacebuilding. Conflict can in turn cause environmental degradation. Environmental justice and governance at global, national and local levels are critical for the achievement of environmental sustainability. Environmental crime, including wildlife trafficking and illegal deforestation (Global Goal 15), can have large impacts on the environment and help fund conflicts. **Knowledge and research gaps relate to: conflicts and the environment (such as the relationship between environmental change and conflict); and law, justice and the environment (such as policy options in response to documented environmental injustice).**

Global Goal 17 covers cross-cutting issues of finance, technology, capacity building, trade, policy and institutional coherence, multi-stakeholder partnerships, and data, monitoring and accountability, i.e. the means for supporting and facilitating implementation of action to achieve the other Global Goals. Addressing these issues is essential to the achievement of all Goals, and to the relationships between Goals.

The syntheses of research evidence, key innovations and policies presented for individual Global Goals show that environment-human interactions are important for the achievement of all of the Goals. However, the number of environment-human interactions, and the extent to which these interactions need to be considered for achieving each Goal, varies among Global Goals. Although research, innovation and policy have advanced substantially since the Millennium Ecosystem Assessment, knowledge and research gaps related to environment-human interactions remain for all Goals.

The Global Goals were conceived as an 'indivisible whole'. The Goals relate to and depend on each other, but relationships between Goals need to be better understood. Previous analyses have begun to explore relationships including synergies and possible conflicts between the Goals from a number of different perspectives and differ widely in their conclusions. While many highlight the role of the more environmentally-focused Goals in underpinning sustainable development, none specifically focuses on environment-human interactions, which are the focus of the TaSE initiative and crucial to the achievement of the Goals.

This report uses a new analysis to suggest which relationships between Global Goals may be most influenced by environment-human interactions. It is based on a pairwise view of relationships between Goals, assessing the influence that action (research, policy, innovation and/or management) towards one Goal may have on the potential for achieving others. It highlights 20 pairwise relationships between Goals where these influences may be especially strong, and illustrates for some of these how the knowledge and research gaps identified in Part 1 are relevant to the relationships between the Goals. In reality relationships among Goals are more complex and multidimensional than a pairwise analysis can illustrate, but visualising all connections among them is challenging. Further knowledge gaps and challenges related to the trade-offs, synergies and unintended consequences of the relationships among Goals will need to be addressed to achieve all 17 Goals.

In order to understand relationships among Global Goals and prioritize action, including research, it is essential to consider multiple cross-cutting factors, including: temporal and spatial scales of action and

impact; context for the action, whether local or other; the (multi) directionality of the relationships among Goals; thresholds and tipping points; number and types of people affected; human behaviour; governance, institutions and power; existence and accessibility of different types of knowledge; and the feasibility of obtaining and scaling-up research results and innovations by 2030. Several approaches have attempted to tackle interconnected challenges, including nexus thinking, pathways, leverage points, indigenous and local knowledge, integrated environmental assessments and integrated modelling. However, there is a need for more work and holistic approaches to achieve all 17 Goals.

The syntheses of research evidence, innovations and policies regarding environment-human interactions relevant to each Global Goal and the analysis of the relationships among Goals provide a basis for identifying priority areas for new research, innovation and policy. The Bellagio Group has a vital role to play in building on this to help the TaSE initiative identify a research, innovation and research translation agenda in support of the Global Goals.

0 *Introduction to Global Goals mapping: the environment-human landscape*

0.1 BACKGROUND

In September 2015, the 193 countries of the United Nations (UN) General Assembly adopted the 2030 Development Agenda, *Transforming our world: the 2030 Agenda for Sustainable Development*, which commits all countries and stakeholders to act in collaborative partnership to end poverty and hunger, and to protect the planet from degradation, so that it can support the needs of present and future generations (2015b). The 2030 Agenda includes 17 Sustainable Development Goals (SDGs), and their 169 targets, to be achieved by 2030 (Box 1, Annex A). These SDGs (known as UN Global Goals for Sustainable Development, and referred to as such in this report) are applicable to all countries, regardless of development status. They build on the UN's Millennium Development Goals (MDGs) (UN 2000), integrate targets from other conventions, such as the UN Convention on Biological Diversity (CBD) Aichi Biodiversity Targets (CBD 2010b), and are influenced by multiple stakeholders, including the private sector. These 17 Global Goals, and their targets, are integrated and indivisible, and balance the three dimensions of sustainable development: economic, social and environmental. The Global Goals came into effect on 1 January 2016. Waage and Yap (2015a) provide a summary of the process that was used to set the Global Goals.

The aim of the Global Goals is to stimulate action over the coming 15 years in areas of critical importance for humanity and the planet (UN 2015b). The implementation of measures to achieve the Global Goals will primarily take place through national decisions on how to incorporate the Goals into national planning processes, policies and strategies; it may involve an increased emphasis on existing national targets, the adaptation of existing targets and associated strategies, or the development of entirely new targets. The Global Goals have also been adopted by a wide range of actors who will enhance the

Box 1: Global Goals for Sustainable Development (also known as Sustainable Development Goals)

Goal 1. End poverty in all its forms everywhere

Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Goal 3. Ensure healthy lives and promote well-being for all at all ages

Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Goal 5. Achieve gender equality and empower all women and girls

Goal 6. Ensure availability and sustainable management of water and sanitation for all

Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all

Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Goal 10. Reduce inequality within and among countries

Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

Goal 12. Ensure sustainable consumption and production patterns

Goal 13. Take urgent action to combat climate change and its impacts*

Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

Goal 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

* Acknowledging that the United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change.

potential for delivery and provide opportunities for collective learning (Müller *et al.* 2016). Indeed, the private sector, civil society organisations and millions of individuals are already engaged in the delivery process.

Environment-human interactions are at the core of progress towards many of the Global Goals. The importance of these interactions was highlighted in the Millennium Ecosystem Assessment (MA) (MA 2005), which emphasised the role of biodiversity and ecosystem services in underpinning human well-being. In recent years, thinking and understanding on environment-human interactions has developed through various research programmes and assessments, such as the UK's Ecosystem Services and Poverty Alleviation programme (ESPA), The Rockefeller Foundation-Lancet Commission on planetary health (Whitmee *et al.* 2015), and assessments conducted through the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES).

Towards a Sustainable Earth initiative

The UK Natural Environment Research Council (NERC), The Rockefeller Foundation (RF), and the UK Economic and Social Research Council (ESRC) recognise that the development challenges of the 21st century require both a shift in thinking and actions that prepare us for the future, while enabling more effective development interventions today. As part of their commitment to seeing the 17 Global Goals become a reality, NERC, RF and ESRC are establishing a new initiative: Towards a Sustainable Earth: Environment-human Systems and the UN Global Goals (TaSE). The statement of intent for TaSE notes that: "The distinguishing feature of this initiative is its core premise that the environment-human relationship must be central to all development. The resilience of our ecosystems, the security of natural resources, and the stability of earth's life-support systems are essential for human resilience to the global changes that we face, and for any prospect of sustainable development. Moreover, a holistic approach to the UN Global Goals will be required in order to implement them successfully, thus we must understand interdependencies, co-benefits and trade-offs across environment-human dimensions of the goals." (NERC *et al.* 2016).

Through a series of convenings hosted at the Bellagio Center, NERC, RF and ESRC will work in partnership to:

1. Identify a research, innovation and research translation Agenda in support of the Global Goals.

2. Develop a process and metrics for tracking progress of the Agenda towards TaSE's high-level objective.

3. Mobilise commitments to funding and action to enable the implementation of the Agenda.

4. Initiate collaboration between, and among, international actors.

The first convening at the Bellagio Center (7-11 November 2016) aims to identify the major research and innovation questions relevant to the achievement of the overarching ambition of the TaSE initiative (Point 1 above). This report, *Global Goals Mapping: The Environment-human Landscape*, is an input into that meeting.

Global Goals Mapping: The Environment-human Landscape

To help focus discussions during the 2016 Bellagio meeting, NERC commissioned the Sussex Sustainability Research Programme (SSRP) at the University of Sussex and the UN Environment World Conservation Monitoring Centre (UNEP-WCMC) to produce a "synthesis of past and current research and innovation relating to the policy landscape surrounding the environment-human relationships and systems that interact across the UN Global Goals" (UK Shared Business Services Ltd 2016).

The commissioned work is framed around three areas:

- relevant past, current and planned research and innovation investments;
- significant research findings, policy drivers and progress since the 2005 Millennium Ecosystem Assessment; and
- the current status of the science-policy landscape that defines the relationship between environment and humanity.

The work will enable the TaSE Steering Group to make informed recommendations about the gaps, opportunities and themes for the Bellagio meeting. The work will help to inform the Bellagio meeting participants to understand the international landscape of current and planned large-scale networks, fora, research, investments, funding instruments and activities supporting the Global Goals within the context of environment-human relationships and systems, and to understand how the TaSE initiative may overlap with and/or complement other initiatives. The work will enable external stakeholders to understand how the TaSE initiative will inform the delivery of the UN Global Goals.

The commissioned work is encapsulated in this report, *Global Goals mapping: the environment-human landscape*; it includes:

- a synthesis of research evidence regarding the environment-human interactions that apply across the Global Goals;

- a synthesis of key innovations and policies that have been used to address environment- human interactions in areas covered by the Goals; and
- an analysis of the relationships between the Goals with respect to environment-human interactions, and the research, innovation and policy evidence relevant to this.

0.2 NAVIGATING THE REPORT

Global Goals Mapping: The Environment-human Landscape comprises:

1) An introductory section (Part 0) covering the background to the report and the Global Goals.
2) **Syntheses of research evidence** regarding the environment-human interactions that apply to each of the Global Goals, **and of key innovations and policies** that have been used to address environment-human interactions in areas covered by each of the Goals (Part 1). The syntheses focus on the scientific literature published after the MA.
3) An **analysis of the relationships between Goals with respect to environment-human interactions**, and the research, innovation and policy evidence relevant to this (Part 2).
4) Two Annexes. The first (Annex A) provides a list of all targets agreed for each Global Goal (for background reference). The second (Annex B) provides details of current and planned large-scale networks, fora, research, investments, funding instruments, and activities supporting the Global Goals within the context of environment-human relationships.

0.3 DEFINITIONS

In this report, we use a broad definition of the 'environment' which encompasses the "totality of all the external conditions affecting the life, development and survival of" humans (Organisation for Economic Co-operation and Development (OECD) 2016) and includes planetary systems (e.g. climate and hydrological systems), geological resources (e.g. mineral and energy resources) and ecosystem capital (land, soil, biological resources, water resources, ecosystem functions) (UN Statistics Division London Group on Environmental Accounting 2014).

We use a broad definition of 'humans' which encompasses people and the knowledge, skills, competencies and attributes embodied in individuals (human capital), as well as the "networks together with shared norms, values and understandings that facilitate co-operation within or among groups" (social capital) (Keeley 2007). Links between individuals and groups, and shared understandings, enable people to work together.

'Environment-human interactions' comprise ways in which the environment and humans affect one another Figure 1. Interactions include both the positive services the environment provides to humans (e.g. provisioning of oil, regulating of climate, etc.) and the negative disservices it provides (e.g. floods, disease, etc.). Interactions also include the positive impacts of humans on the environment (e.g. protecting and restoring ecosystems, conserving species, etc.) and the negative impacts of humans (e.g. pollution of water, degradation of soils, etc.). Interactions may be positive or negative, weak or strong, and can vary in their certainty; our level of understanding of such interactions may also vary.

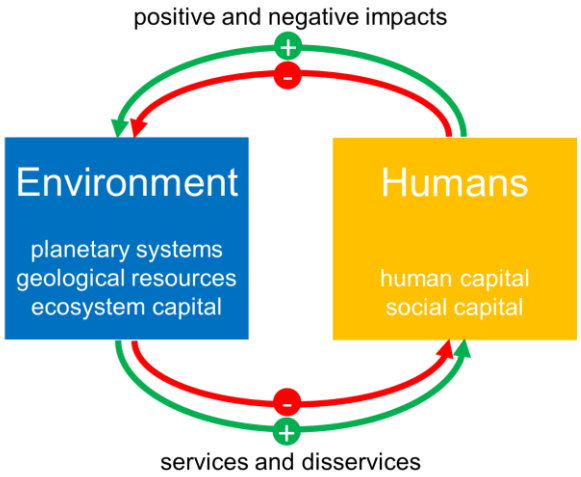


Figure 1. Overview of four potential types of environment-human interactions.

'Research' comprises creative and systematic work undertaken in order to increase the stock of knowledge (including knowledge of humankind, culture and society) and to devise new applications of available knowledge (OECD 2015b). Research includes basic, strategic and applied research.

By 'innovation' we mean new ways of doing things. Innovation not only includes science and technology, but the related array of new ideas, institutions, practices, behaviours and social relations that shape scientific and technological patterns, purposes, applications and outcomes (STEPS Centre 2010).

A 'policy' is often defined as a course or principle of action adopted or proposed by an individual or organisation (including businesses, governments, conventions, agreements, etc.). It is often envisaged as a single, linear process in which rational decisions are taken by those with authority and responsibility for a particular policy area. Here, rather than seeing policy as a single

decision implemented linearly, we consider policy to include a broad course of action (or inaction) of incremental, complex and messy interrelated decisions that evolve over time during an inherently political process that may involve overlapping and competing agendas (Keeley *et al.* 1999).

'Action' to achieve one or multiple Global Goals is considered to encompass research, innovation, policy, debate and/or management.

1 Syntheses of research evidence regarding the environment-human interactions that apply across the UN Global Goals, and key innovations and policies that have been used to address environment-human interactions in areas covered by the goals

1.1 INTRODUCTION

Part 1 provides **syntheses of research evidence** regarding the environment-human interactions that apply across the United Nation's (UN) Global Goals for Sustainable Development, and of **key innovations and policies** that have been used to address environment-human interactions in areas covered by the Goals.

Environment-human interactions are at the core of progress towards many of the Global Goals and their targets. The importance of these interactions was highlighted in the 2005 Millennium Ecosystem Assessment (MA) (MA 2005), which emphasised the role of biodiversity and ecosystem services in underpinning human well-being. Understanding of these interactions has been developed further by research programmes, such as the UK's Ecosystem Services and Poverty Alleviation programme (ESPA), the Rockefeller Foundation-Lancet Commission on Planetary Health (Whitmee *et al.* 2015), and assessments, including those being conducted through the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES). The core premise that environment-human interactions are central to sustainable development provided the inspiration for NERC, Rockefeller Foundation and ESRC to launch the Towards a Sustainable Earth: Environment-human Systems and the UN Global Goals (TaSE) initiative (see Part 0).

The conceptualisation of sustainable development has changed from the original framing of three pillars of sustainability (i.e. social, environmental and economic) to a more integrated framing, showing society and economy as concentric circles within a larger circle representing the Earth's life support systems (Griggs *et al.* 2013) (Figure 2). Previous research has classified the Global Goals into broad types: 'environmental' or 'human'. As such, Griggs *et al.* (2014) categorised the targets of an early draft of the Sustainable Development Goals into 'biophysical', 'integrated' and 'social'. More recently, focusing on the governance of the Goals, Waage *et al.* (2015b) suggested a classification containing the 'natural environment goals' as the outermost circle of a concentric circle diagram, with 'infrastructure' and 'wellbeing' as inner circles.

Environment-human interactions are critical to the achievement of all the Global Goals. Even if the main focus of a Goal is the state of human society or the economy, management of the environment can be essential for its achievement. For instance, climate, and our management of it, is fundamental to growing food and, therefore, achieving Goal 2. However, the degree to which environment-human interactions need to be considered in order to achieve all of the different components of a Goal varies among the 17 Global Goals. The extent to which environment-human interactions need to be considered for the achievement of each Global Goal is not readily measurable. This is because there are multiple targets within each Goal, each with different amounts and kinds of environment-human interactions.

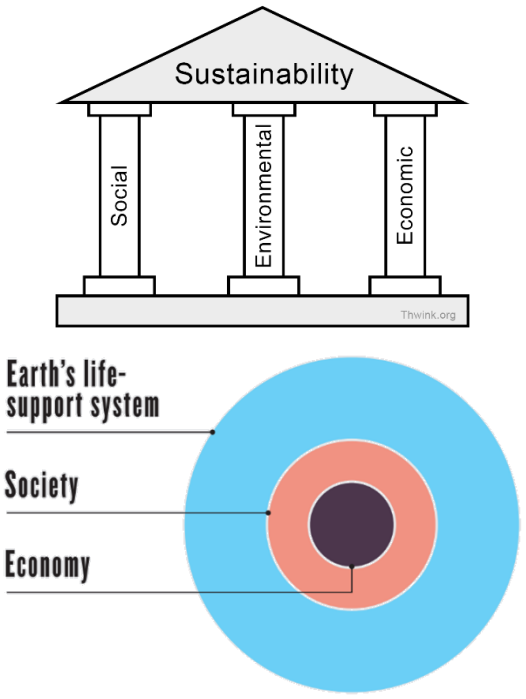


Figure 2. Two ways to visualise environmental, social, economic aspects of sustainability. From thwink.org and Griggs *et al.* (2013).

There are potentially four different types of environment-human interactions that need to be considered: services, disservices, positive impacts and negative impacts (Figure 1). Furthermore, there are a range of potential 'actions' that involve environment-human interactions to a greater or lesser extent (such as research, policy, innovations, debate, management, behaviour change) which might be employed to achieve a Global Goal.

When environment-human interactions were reviewed as part of the MA, a number of information needs were encountered (Carpenter *et al.* 2006). The MA found that a robust theoretical basis for linking biological diversity to ecosystem dynamics and ecosystem services, and linking ecosystem services and human well-being were lacking. Furthermore, we lack the ability to predict thresholds and nonlinear shifts in ecosystems. It also identified issues with assessing ecosystem services at global scales, and matching up different scales. A lack of monitoring and data (including time series data and information on the location of desertification and wetlands) was recognised as a major issue. Additionally, the lack of policy assessments and economic instruments and valuations was identified, and the challenge of linking social to ecosystem change was noted. Since 2005, there have been many developments in research, innovation and policy to address environment-human interactions important for each of the Global Goals. This research has partly responded to the MA research gaps, although many gaps still remain.

1.1.1 Methodology for Part 1

To provide an overview of the main developments since the MA in 2005 in research, innovation and policy that address environment-human interactions relevant to each of the Global Goals, we have focused on synthesising existing reviews and assessments. Published reviews, syntheses and assessments were identified using databases (such as Web of Knowledge and Google Scholar), as well as harnessing expert knowledge. We drew on expert knowledge from across the organisations involved in this project – UNEP-WCMC and the Sussex Sustainability Research Programme (SSRP, consisting of the University of Sussex and the Institute of Development Studies) – and from our advisory group members. Additionally, semi-structured interviews were undertaken with 16 leading experts working on different topics related to the Global Goals; these experts were identified through recommendations of colleagues, the TaSE steering committee and internet searches. Where possible, we focused on synthesising the conclusions of global reviews and assessments, rather than more local or national reports. As the report focused on existing global reviews and assessments, rather than primary literature, we have relied on them to provide a regionally balanced perspective. We have highlighted in the report where only regional or national information was available. We have also assumed that the global reviews and assessments have considered issues of gender and indigenous and local knowledge. However, we recognise that, through the use of global assessments and scientific reviews, this report may have missed out important indigenous and local knowledge, which a larger assessment might capture.

Gaps in knowledge were identified by summarising the gaps identified in published reviews and syntheses. Therefore, the report presents an overview based on the published literature, which may not be unbiased or complete. Our report reflects the currently known and reported unknowns, rather than any unknown unknowns. Networks and funding were identified through expert knowledge, interviews and targeted internet searches.

Given the limited time available and the need for a rapid assessment, the reader should note that the syntheses and gaps presented here are not comprehensive, neither are the list of networks and funding programmes.

1.1.2 Outline

Part 1 of this report provides syntheses of research evidence, innovations and policies for each Global Goal separately. Ultimately, the 17 Global Goals, and their achievement, are integrated and indivisible. Syntheses are presented separately for each Global Goal simply for convenience. To highlight the integrated and indivisible nature of the Global Goals, we have inserted cross-references among key areas and issues where Goals are strongly interconnected.

Each Global Goal chapter comprises the following:

Section 1 – a summary of the Goal and policy context for the Goal.

Section 2 – key environmental-human interactions, including an overview about the relevant environment-human interactions from the MA.

Section 3 – the main part of each Global Goal chapter, provides a synthesis of recent developments in research, innovations and policies relevant to environment-human interactions.

Section 4 – knowledge and research gaps that have been reported by published syntheses and assessments.

Section 5 – an overview of past, current and future networks and funding programmes. A longer, but not comprehensive, list of identified networks and funding programmes are provided in Annex B.

1.2 GLOBAL GOAL 1: END POVERTY IN ALL ITS FORMS EVERYWHERE

1.2.1 Summary of Global Goal

Global Goal 1 calls for an end to poverty in all its manifestations by 2030. It aims to ensure social protection for the poor and vulnerable, increase access to basic services, and support people harmed by climate-related extreme events and other economic, social and environmental shocks and disasters (UN 2016c). This Global Goal also aims to ensure that men and women have equal rights to economic resources, as well as access to basic services, and ownership and control over land and other forms of property, including natural resources.

A large number of global environmental agreements are relevant to the objectives of Global Goal 1. For example, the mission of the Convention on Biological Diversity's (CBD) latest Strategic Plan (2011-2020) is to halt the loss of biodiversity, thereby contributing to human well-being and poverty eradication (CBD 2010b). In particular, Strategic Goal D of the Plan links to poverty by aiming to enhance the benefits to all from biodiversity and ecosystem services, including through safeguarding ecosystems that provide essential services which contribute to livelihoods and well-being. In relation to supporting people harmed by climate-related extreme events, the United Nations Framework Convention on Climate Change (UNFCCC) and the Sendai Framework for Disaster Risk Reduction 2015-2030 both address the interconnections between climate change and poverty, providing a global mandate for Member States to act upon.

1.2.2 Overview of main environment-human interactions

The close connections between environmental health and human well-being have long been recognised. The Millennium Ecosystem Assessment (MA) (2005), examined the consequences of changes in ecosystems on human well-being, presenting evidence that "the harmful effects of the degradation of ecosystem services on livelihoods, health, and local and national economies are substantial". Furthermore, the MA explored the relationships between environmental management and poverty reduction, showing how shifts in indirect drivers of ecosystem change (e.g. population) can impact direct drivers of change (e.g. fish catch), resulting in changes in ecosystems and their services that affect human well-being.

As many ecosystems have not been monitored, the MA pointed out that it can be difficult to "estimate the influence of changes in ecosystem services relative to other social, cultural, and economic factors that also affect human wellbeing". Nonetheless, there is an overall trend of ecosystem degradation negatively impacting the poor, particularly as they may rely heavily on natural resources for their livelihoods (CBD 2010a), and are the most vulnerable to extreme environmental and climatic events (UNDP-UNEP 2009). Yet, as the MA found, diverse ecosystems play an important role in reducing communities' vulnerability to such extreme events and shocks. Indeed, with diverse ecosystems, more livelihood options become available; and most communities try to maintain a diverse range of livelihood options as "this diversity buffers people against shocks and surprises such as climatic and economic fluctuations" (MA 2005). Many complex interactions must, therefore, be taken into account when considering the environment-human nexus in relation to Global Goal 1.

1.2.3 Synthesis of development in research, innovation and policies

Linking the environment and poverty

Complex, multidimensional relationships.

The linkages between the environment and poverty are highly complex, dynamic, multiscalar and differential (Carr *et al.* 2009). Environment-poverty links can be positive and negative (for example, poverty can exacerbate or reduce biodiversity loss, and vice versa), and are experienced differently by different individuals and groups across diverse geographic, economic, social and cultural contexts (UNDP-UNEP 2009). Although environment-poverty linkages can be conceptualised in many ways, some important overarching areas include links to livelihoods, resilience to environmental risks, health (Global Goal 4) and economic development (Global Goal 8) (UNDP & UNEP 2009). When considering such relationships, it is not only important to take into account the multitude of complexities between the environment and poverty, but also their internal complexities – the physical environment, alone, is characterised by countless ecological and biophysical processes and interactions that change in response to a plethora of drivers. The complexity of poverty has also become increasingly recognised, moving beyond the unidimensional focus on income, towards building an understanding of its multidimensionality (Alkire 2007). In response, the multidimensional poverty index (MPI) (Alkire *et al.* 2011; Alkire *et al.* 2014) has been developed to consider health, education, living standards and various sub-categories. It measures several

dimensions identified as contributing to poverty, but that were not previously captured under the Millennium Development Goals (MDGs). The MPI is now being considered as a potential indicator for certain Global Goals (UNSDS 2015).

In order to better understand the links between the environment and poverty, it is important to appreciate the multidimensionality of the two concepts themselves. Indeed, recent work Schleicher *et al*. (in prep.) has considered the value of integrating the natural environment as an additional dimension of poverty. This is because the lack of access to, or deprivation from, the natural environment can be perceived as a form of poverty in itself, as well as driving other dimensions of poverty (such as health; Global Goal 3).

Ecosystem services, biodiversity and poverty alleviation.

Much of the recent research aimed at improving our understanding of the complex linkages between the environment and poverty has focused on the interactions between poverty and ecosystem services. A number of reviews have investigated the links between ecosystem services and poverty alleviation or well-being through conceptual frameworks (Agarwala *et al.* 2014; Fisher *et al.* 2014), as well as trying to understand the trade-offs between the two spheres (Howe *et al.* 2014). Most recently, Suich *et al.* (2015) reviewed the state of knowledge regarding the mechanisms linking ecosystem services and poverty alleviation. This study found that, to date, research has focused largely on provisioning services, and on just two poverty dimensions concerning income/assets and food security/nutrition (Global Goal 2) (Suich *et al.* 2015). Although many studies describe links between ecosystem services and dimensions of poverty, few provide sufficient context to enable a thorough understanding of the positive or negative poverty alleviation impacts (if any) of ecosystem services, or the direction of causality (Suich *et al.* 2015). The research available does, however, provide evidence that ecosystem services support well-being and are likely to prevent people from becoming poorer, especially in rural areas of developing countries (Suich *et al.* 2015).

Similar findings have been emerging from recent research focusing on biodiversity, its conservation and its interactions with poverty. Although there is an explicit assumption – in particular, in international policy statements – that conserving biodiversity, or reducing its rate of loss, will help tackle global poverty (Roe *et al.* 2013a), reviews of the evidence base for this assumption have found a surprising lack of empirical data to support such a direct relationship (Vira *et al.* 2013; Roe *et al.* 2014). An edited volume dedicated to exploring this relationship (Roe *et al.* 2013c) concluded that the contribution of biodiversity and its conservation to poverty alleviation at the individual or household level varies hugely from context to context; i.e. it can contribute to poverty alleviation "for *some* people in *some* places" (Roe *et al.* 2013b). Despite the limited evidence base, the volume was able to confirm that the poor do often depend disproportionately on biodiversity for their subsistence needs. Indeed, biodiversity is a form of natural capital for the rural poor, providing both subsistence and income (Roe *et al.* 2014; Djoudi *et al.* 2015). For example, a comparative analysis of environmental income from approximately 8,000 households in 24 developing countries revealed that it accounted for 28 per cent of total household income, 77 per cent of which came from natural forests (Angelsen *et al.* 2014). In addition to the importance of environmental incomes (Vira *et al.* 2013; Roe *et al.* 2014), biodiversity provides the poor with an easily accessible form of insurance against risk, particularly in relation to health, environmental hazards and food security (Global Goals 3, 13, 2) (Roe *et al.* 2013b). For instance, harvesting wild biodiversity can act as a safety net by providing a source of income at times of the year when other sources of income are low (e.g. agricultural revenues in times of low production), thereby preventing the poor from becoming poorer during such 'lean seasons' (Roe *et al.* 2013b; Vira *et al.* 2013).

Despite the wide array of potential positive interactions between biodiversity and poverty alleviation, a number of negative relationships have been documented. There is some evidence that poorer people often only have access to the least valuable natural resources, and are excluded from accessing more highly valued resources. This catches them in a 'poverty trap' in which they are confined to low-value uses of such resources and are unable to transition out of poverty (Vira *et al.* 2013). Furthermore, interventions put in place to conserve biodiversity (Global Goals 14, 15), which are inevitably influenced by politics, power relations and governance issues, may exacerbate poverty. Strict enforcement of protected areas, for instance, can restrict the poor from accessing natural resources, increasing local incidence of poverty (Roe *et al.* 2013b). Our understanding of these relationship is limited, however, due to a lack of comparable studies, historical baselines and counterfactual control sites (Roe *et al.* 2013b).

Ensuring rights to land and natural resources

Securing the rights to land and natural resources is an important factor influencing the dynamics between the environment and poverty. It is crucial for the rural poor, in particular, to have rights to land and natural resources, such as forests,

fisheries and pastures, as they often directly depend on them for their livelihoods (Mwangi *et al.* 2009). Furthermore, property rights over a form of housing or homestead provide shelter, dignity and a means for accumulation (Meinzen-Dick 2009). Land can be used as collateral for credit to further invest in the plot, or may be exchanged for capital to start up another income-generating activity (Meinzen-Dick 2009). In the case of many poor people, the latter is a common strategy as multiple income-generating activities can help to maintain current consumption patterns (Global Goal 12) and provide pathways out of poverty (Mwangi *et al.* 2009). In particular in times of shock, being able to fall back on land, and the resources derived from it, can help landowners survive and rebound; whereas, the landless do not have such opportunities, so are often among the poorest (Meinzen-Dick 2009). In addition to such economic benefits, rights to land and resources also fulfil a number of social functions, including increased social standing, greater respect and a stronger connection with the community, which, in turn, can increase their access to government services, and their influence within local politics (Meinzen-Dick 2009).

Research has shown that communities and indigenous people can be sustainable stewards of the environment if they have the necessary rights with which to benefit from their land and natural resources, as well as to defend them from outsiders (Ostrom 1990; Roe *et al.* 2009; Persha *et al.* 2011; Oxfam *et al.* 2016). Despite this fact, a recent report by Oxfam, the International Land Coalition, and Rights and Resources Initiative (2006) noted that less than one fifth of all traditional lands are currently under community ownership, and land grabs are increasingly fuelling conflicts in dozens of countries. Furthermore, women struggle far more than men to acquire rights to land, putting them at an even greater disadvantage in terms transitioning out of poverty (Global Goal 5) (Meinzen-Dick 2009). To counteract these issues, numerous land reforms have been promoted around the world (Meinzen-Dick 2009), but they remain insufficient. In fact, caution needs to be taken as to the type of legal reform necessary to strengthen the land tenure of poor people (Meinzen-Dick 2009). As Meinzen-Dick (2009) has noted: "simplifying land rights to give complete authority to the owner of the underlying land […] can cut off other claims important for the livelihoods, social standing, or security of others, with the poor and marginalised groups and individuals often suffering most". Therefore, care needs to be taken when formalising land rights in order to avoid reconfirming and legitimising practices of exploitation, or reinforcing power asymmetries between the poor and the elite (Wittmer *et al.* 2013). Local variations in such secondary property rights, as well as local power dynamics in relation to natural resource management, are often not taken into account in state-level reforms (Wittmer *et al.* 2013), thus minimising their potential benefits for both humans and the environment.

Exposure and vulnerability to climate-related extreme events and other environmental shocks

It has been estimated that, without concerted action, there could be up to 325 million extremely poor people living in the 49 countries most exposed to the full range of natural hazards and climate extremes in 2030 (Shepherd *et al.* 2013). Natural disasters range from biological disasters, such as epidemics and insect infestations, to climate-related disasters, such as droughts, storms, floods, extreme temperature and wildfires, and geophysical disasters, such as earthquakes and volcanoes. The impacts of natural disasters can create a downward spiral by negatively impacting on the economy and increasing poverty, thus increasing the vulnerability of the population to future natural disasters (Sodhi 2016). From 1980 to 2012, natural disaster-related losses amounted to USD 3,800 billion worldwide (World Bank 2013). Biological disasters have a particularly significant impact on human health (Global Goal 3).

Between 1980 to 2012, 87 per cent of reported natural disasters (18,200 events) were caused by weather extremes (World Bank 2013). Moreover, weather extremes caused 74 per cent of economic losses (USD 2,800 billion) and 61 per cent of lives lost (1.4 million in total) from natural disasters (World Bank 2013). The Intergovernmental Panel on Climate Change's (IPCC) latest assessment report (Edenhofer *et al.* 2014) provides the most up-to-date review of the impacts of climate-related extreme events (Global Goal 13). It highlights climate change will amplify existing risks, and create new ones, for natural and human systems (Edenhofer *et al.* 2014). Such risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development (Edenhofer *et al.* 2014). Overall, disaster-risk management should be a key component of reducing poverty, and should focus on protecting livelihoods, as well as saving lives (Shepherd *et al.* 2013). Indeed, sustainable development cannot be achieved without consideration of risk and vulnerability from natural disasters (Surjan *et al.* 2016).

Role of the environment in reducing climate and non-climate risks

There is increasing recognition of the role of ecosystems in Disaster Risk Reduction (DRR), and EcoDRR (ecosystem-based DRR) is becoming a widely acknowledged concept. Similarly, there has been increasing appreciation of the role of ecosystems in climate change

adaptation (i.e. ecosystem-based adaptation [EBA]). The close relationship between EcoDRR and EBA is being widely noted, as is the need to learn lessons from the different fields of work (UNEP 2015f). A UN review (Renaud *et al.* 2013) of the role of ecosystems in DRR highlighted that healthy and well-managed ecosystems can serve as natural infrastructure to prevent hazards, or to buffer hazard impacts, and reduce the exposure of people and their productive assets to hazards; for example:

- In mountainous areas, vegetation protects against erosion and increases slope stability by binding soil together, preventing many types of landslides.
- Well-managed protection forests can be effective in safeguarding against rock fall and reducing the risk of avalanches.
- Coastal wetlands, tidal flats, deltas and estuaries absorb water from upland areas, storm surges and tidal waves.
- Coral reefs, sea grasses, sand dunes and coastal vegetation, such as mangroves and saltmarshes, can reduce wave heights and decrease erosion from storms and high tides.
- Healthy peatlands, wet grasslands and floodplains can help to control floods and reduce flood risk.
- In drylands, maintaining vegetation cover and agricultural practices, such as the use of shadow crops, increases resilience to drought by conserving soil and retaining moisture.

Well-managed, healthy ecosystems can also reduce human vulnerabilities to natural disasters by supporting livelihoods that are sustainable and resilient to such disasters, and by supporting the during- and post-disaster recovery needs of communities (Renaud *et al.* 2013).

In addition to the UNEP review of all DRR, there have been a number of other reviews on specific risks, and risks in different environments. For instance, Cunniff *et al.* (2015) show that there is high confidence and data availability on the role of restored coral reefs in reducing short-wave attenuation and reducing coastal erosion; but there is limited confidence and available information on their role in storm surges, and reducing the force and height of medium waves.

1.2.4 Knowledge and research gaps

Interrelationships between ecosystem services, biodiversity and poverty alleviation

Further evidence is needed on:

- The causal links between biodiversity and poverty (Roe *et al.* 2014), and ecosystem services and poverty, going beyond the currently observed relationships, especially in terms of bundles of ecosystem services and regulating services (Suich *et al.* 2015).
- The multidimensionality of poverty. Analyses that combine consideration of income and assets with other non-income dimensions of poverty (Suich *et al.* 2015) are required; they should include research that examines bundles of ecosystem services, multiple dimensions of poverty, and the direct and indirect linkages between these elements (Suich *et al.* 2015).
- Understanding the feedback mechanisms within, and between, the dimensions of poverty and bundles of ecosystem services, including related net outcomes from the full range of (expected and unexpected) costs and benefits, and how these outcomes are distributed between, and within, social groups (Suich *et al.* 2015).
- The importance of biological diversity to poverty alleviation, rather than the abundance of biodiversity per se. Furthermore, an improved understanding of biodiversity as 'insurance' to cover seasonal needs is much needed (Roe *et al.* 2013c).
- Systematic and consistent consideration of mediating factors that are important to the ways in which changes in ecosystem services or poverty affect the rest of the socio-ecological system; this will help to determine the conditions under which the use of ecosystem services are most likely to contribute to poverty alleviation (Suich *et al.* 2015).
- Ecosystem disservices and costs, as well as the trade-offs between, and within, ecosystem services and poverty alleviation (Sandbrook *et al.* 2015; Suich *et al.* 2015).
- Differentiated impacts of poverty reduction programmes and empowering the poor on ecosystem services, biodiversity and the environment more generally (Roe *et al.* 2013c).
- Urban ecosystems and drylands as research in these ecosystems is currently scarce (Suich *et al.* 2015) (Roe *et al.* 2013c).

Role of ecosystems in reducing impacts of natural disasters

Renaud *et al.* (2013) highlight a number of gaps in evidence, including:

- The role of ecosystems in DRR (current evidence is contradictory or misperceived).
- The role of coastal vegetation in buffering against extreme events, such as cyclones or tsunamis (as opposed to the well-established role of vegetation in protecting coastal areas against erosion or the impacts of storm surges).
- The linkages between vegetation and/or forest cover and flooding (while it is often perceived that increased forest cover decreases the

likelihood of floods, this is still scientifically debated).
- The linkages between, and complexities of, vulnerability, risk and environmental factors (without overemphasizing the role of ecosystems in DRR – ecosystems and society are intertwined, but other factors explaining the underlying vulnerability of the exposed communities need to be taken into account when considering DRR interventions).

1.2.5 Overview of networks and funding

A large number of institutions, non-governmental organisations (NGOs) and research groups are dedicated to working on various aspects of the environment-poverty nexus around the globe. Within the UN system, the UN Development Programme-UN Environment Programme (UNDP-UNEP) Poverty-Environment Initiative supports country-led efforts to put pro-poor, pro-environment objectives into the heart of government by mainstreaming poverty-environment objectives into national planning. The Initiative is currently funded by the Governments of Norway, Spain, Sweden and the UK, and the EU. Other prominent organisations focusing on the links between the environment and poverty include the Poverty Environment Network (PEN), which undertook the largest and most comprehensive global analysis of tropical forests and poverty. The PEN is also the leading index of poverty-environment knowledge and resources. The Poverty-Environment Partnership (PEP) and IIED's Poverty and Conservation Learning Group are both information-sharing networks of like-minded organisations and individuals.

In relation to environmental shocks, the Partnership for Environment and Disaster Risk Reduction acts as a global thematic platform for the International Strategy for Disaster Reduction (ISDR). It seeks to promote and scale up implementation of EcoDRR and to ensure it is mainstreamed in development planning. The ISDR, established in 1999, is a system of partnerships that aims to generate and support a global DRR movement to reduce risk to disasters. The United Nations Office for Disaster Risk Reduction (UNISDR) is the UN body responsible for DRR.

1.3 GLOBAL GOAL 2: END HUNGER, ACHIEVE FOOD SECURITY AND IMPROVED NUTRITION, AND PROMOTE SUSTAINABLE AGRICULTURE

1.3.1 Summary of Global Goal

Global Goal 2 aims to end hunger and all forms of malnutrition by 2030. It also commits to universal access to safe, nutritious and sufficient food at all times of the year. This requires sustainable food production systems and resilient agricultural practices, equal access to land, technology and markets, and international cooperation on investments in infrastructure and technology to boost agricultural productivity (UN 2016c).

The aims of Global Goal 2 are mirrored in other multilateral environmental agreements. Aichi Biodiversity Target 7 of the Convention on Biological Diversity (CBD) states that, by 2020, areas under agriculture, aquaculture and forestry will be managed sustainably in order to ensure the conservation of biodiversity. In addition, Aichi Biodiversity Target 8 declares that, by 2020, pollution, including from excess nutrients, will be brought to levels that are not detrimental to ecosystem function or biodiversity.

1.3.2 Overview of main environment-human interactions

The world has made substantial progress in reducing hunger and malnutrition over the past 25 years, with global rates of hunger falling to 1 in 10 people, and the proportion of children who are chronically undernourished declining to around 1 in 4 (GloPan 2016). Poor diets constitute the number-one driver of the global burden of disease (Global Goal 3). Sustainable management and use of the environment (Global Goal 12) is key to ending hunger, malnutrition (Global Goal 3) and food insecurity.

All food is ultimately derived from the environment. The MA (2005) highlighted that food production has increased by around 168 per cent over the past 42 years, yet major distributional inequalities still exist (Global Goal 10). Increasing incomes, urbanisation and changing diets have increased food consumption in most areas of the world, however, there is doubt about achieving yield growth into the future to ensure global food security and environmental sustainability (MA, 2005). Intensified livestock production poses serious waste problems and increased demands for water and fertilizers. The productivity of crops grown for human consumption is at risk due to the incidence of pests and pathogens. Furthermore, practices like slash-and-burn agriculture, if unsustainable, can cause soil degradation and nutrient losses (Amorim *et al.* 2014). Water also has a central role in global food production, and the management of catchments and sustainable use of water for agriculture is critical (Global Goals 6 and 15).

During the next 40 years, production will need to increase by about 70 per cent to cope with population increases and demands for meat, dairy and other products. There will be increased competition for land and water from growing urban populations, counteracted by an increased reluctance to see natural landscapes converted to agricultural uses. Achieving this Goal will depend on both reducing demand (for instance, through healthier diets and decreasing waste) and increasing supply.

1.3.3 Synthesis of developments in research, innovations and policies

Exploitation of environmental resources

Agriculture, water and land use

Currently, most global agricultural practices are unsustainable. Overexploitation of environmental resources and the production of pollutants are rife. The livestock sector is by far the single largest anthropogenic user of land. Livestock production accounts for 70 per cent of all agricultural land and 30 per cent of the terrestrial surface of the planet (Steinfeld *et al.* 2006); it is also a key factor in deforestation and degradation in dry areas. Land degradation and soil loss may be limited and reversed through: soil conservation; silvopastoralism (combining forestry and grazing); better management of grazing systems; limits to uncontrolled burning by pastoralists; and controlled exclusion from sensitive areas (Global Goal 15) (Steinfeld *et al.* 2006). There is still debate over whether land-sharing (low-yield farming that encourages biodiversity within agriculture) or land-sparing (high-yield farming of smaller land areas, but with specific areas spared for wildlife) better balances food production with conservation. In addition, the balance between, and environmental impacts of, small-scale farming and industrialised, large-scale farming (including 'land grabbing' – large-scale acquisitions of land) remains to be resolved.

Groundwater resources sustain an increasing share of irrigated agricultural production. Currently, agriculture accounts for 70 per cent of global freshwater withdrawal (Turral *et al.* 2012). Intensive groundwater use has proved almost impossible to regulate, and can result in stream depletion, salinisation of coastal aquifers, and land subsidence (OECD 2015a). Estimates of incremental water requirement to meet future demand for agricultural production under climate change vary from 40 per cent to 100 per cent of the extra water needed without global warming. In future, emerging competition between the environment and agriculture will likely result in a reduction in water availability (FAO 2011c) (Global Goal 6).

Wild food provision.

Wild animals from land and sea are the main source of protein for 1 billion people, and 15 per cent of the global population rely on them for their livelihoods (Brashares *et al.* 2014). Overexploitation is one of the main threats to biodiversity (Schipper *et al.* 2008; Maxwell *et al.* 2016); although there is actually limited data on exploitation (Joppa *et al.* 2016). As an example of overexploitation, hunting for food is of concern for the environment for three main reasons: (i) there is strong evidence that hunting poses a risk to many species; (ii) the depletion of wildlife is linked to food security and livelihoods; and (iii) the links between hunting and wildlife trade are poorly understood (Nasi *et al.* 2008). Additionally, diseases and infections are mediated by the environment through the consumption and harvest of wildlife (Global Goal 3).

Food sourced from the oceans also sustains people worldwide (Global Goal 14), and insects form part of the traditional diets of at least 2 billion people – more than 1,900 species have reportedly been used. Fish and insects as food and feed emerge as an especially relevant issue in the 21st century due to the rising cost of animal protein, food and feed insecurity, environmental pressures, and an increasing demand for protein. The environmental benefits of rearing insects for protein are the high feed-conversion efficiency, the ability to rear them on organic human and animal waste, and fewer greenhouse gases and ammonia emissions than cattle or pigs, and they require less land and water than cattle rearing (van Huis *et al.* 2013).

Pollution and other environmental impacts

Water pollutants from agriculture include nutrients, pesticides, soil sediments and other contaminants which run-off fields or leach into water systems (groundwater, marine and coastal waters) and soils. It is likely that the overall economic, environmental and social costs of water pollution caused by agriculture in OECD countries exceeds billions of dollars per year. The outlook over the next 10 years for agriculture and water quality suggests that the growth and intensification of agricultural production could further heighten regional pressures on water systems in some countries, and may be exacerbated by climate change (Global Goal 6) (OECD 2012b). Pollutants from aquaculture are discussed in Global Goal 14.

Agriculture contributes 14 per cent of global annual greenhouse gas emissions and indirectly accounts for another 4 to 8 per cent of emissions from forest clearance for rangeland and arable development (McMichael *et al.* 2007). Carbon dioxide is generated by fossil fuels used in cultivation, transport, crop processing, pumping irrigation water, livestock production, and in the

production of nitrogenous fertiliser. Inefficient and excessive use of artificial, nitrogenous fertilisers generates nitrous oxide, a short-lived, but more damaging, greenhouse gas. Methane, another potent greenhouse gas, is generated by ruminant livestock and wet-rice cultivation (McMichael *et al.* 2007).

Humans continue to transform the global nitrogen cycle at a record pace, reflecting an increased combustion of fossil fuels, growing demand for nitrogen in agriculture and industry, and pervasive inefficiencies in its use (Global Goals 7, 9, 12). Substantial and sustained intervention is needed in regions that do not have sufficient nutrients to sustain their population. In such regions, it will be important to seek ways to increase food production that minimise nutrient loss and soil degradation, and their subsequent environmental damages (Galloway *et al.* 2008).

Climate change may significantly impact agricultural production by increasing water demand, limiting crop productivity and reducing water availability in some areas (FAO 2011c; Liu *et al.* 2016) (Global Goal 6, 13). Without deliberate adaptation or the positive effects of carbon dioxide fertilisation, a 1°C global temperature rise is projected to result in wheat-yield declines of 4.1 to 6.4 per cent (Liu *et al.* 2016). The agriculture sector is particularly exposed to risks of floods and droughts, which may become more frequent and severe due to climate change (OECD 2016b). No-till agriculture has climate mitigation potential due to carbon sequestration (UNEP 2013b) and reduced tillage can contribute to climate change adaptation through building agricultural systems that are more resilient to climate and weather variability (Powlson *et al.* 2014). Climate-smart agriculture integrates the three dimensions of sustainable development (economic, social and environmental) by jointly addressing climate challenges and food security. It is composed of three main pillars: (i) sustainably increasing agricultural productivity and incomes; (ii) adapting and/or building resilience to climate change; and (iii) reducing and/or removing greenhouse gas emissions (FAO 2010).

The environmental impacts of intensive agriculture detailed here could be reduced by addressing the issue of food wastage (UNEP 2016). Worldwide, one-third of food produced for human consumption is lost or wasted, which amounts to around 1.3 billion tonnes per year throughout the supply chain. Per capita food waste by consumers in Europe and North America is estimated to be 95-115 kg per year, and 6-11 kg per year in Sub-Saharan Africa and South/Southeast Asia (FAO 2011b) (Global Goal 12).

Role of the environment in supporting sustainable and resilient agricultural practices

Agrobiodiversity, crop pollination and biological control

Approaches have been developed that incorporate biodiversity within agricultural systems. The use of multi-species and multi-breed herds and flocks, for example, are used by many traditional livestock farmers to maintain high diversity in on-farm niches and to buffer against climatic and economic adversities. Species combinations also enhance productivity and yields in aquatic systems. Crop rotations, intercropping and growing different varieties of a single crop have all been shown to have beneficial effects on crop performance, nutrient availability, pest and disease control, and water management. Furthermore, multi-cropping, intercropping, alley farming, rotations and cover-cropping are all ways of combining crop species that have positive effects on productivity and yield stability (PAR *et al.* 2011).

The role of flower-visiting animals in global crop production (5 to 8 per cent by value) of agricultural output is well established (IPBES 2016a). Although bees are considered the most important pollinator group, other insects, such as flies and butterflies, also contribute to agricultural output (Rader *et al.* 2016). Bee declines (Nieto *et al.* 2014) are primarily driven by combined stress from parasites, pesticides and a lack of flowers (Goulson *et al.* 2015; IPBES 2016a). There is no global 'red list' for insect pollinators, but available national assessments show that more than 40 per cent of bee species may be threatened (IPBES 2016a). A relatively new class of insecticide, neonicotinoids (in use since 1991), has been strongly implicated as a key factor.

The productivity of crops grown for human consumption is at risk because of the increase of plant pests (especially weeds), pathogens and animal pests. However, the inappropriate and excessive use of pesticides have led to pest outbreaks and losses in some crops because of the inadvertent destruction of the natural enemies of pests, pest resistance and secondary pests (Oerke 2006). As such, biological control is a key component of a 'systems approach' to integrated pest management (IPM); it counteracts insecticide-resistant pests and has been shown to reduce pesticide usage in several economically important crops (Turall 2012). Over the past century, more than 6,000 introductions of about 2,000 different insect species for biological control have occurred in 172 countries (Cock *et al.* 2016), with few environmental problems (Hajek *et al.* 2007; Bale *et al.* 2008). Although uptake has been slow, biological control is expected to account for a significantly increased proportion of

all crop protection methods by the year 2050 (Bale *et al.* 2008; Cock *et al.* 2016).

Future directions in sustainable production and resilience

Biotechnology and resilience

There are many environmental processes that can undermine food production. For example, weeds produce the highest potential loss to agricultural productivity (34 per cent), followed by animal pests (18 per cent) and pathogens (16 per cent). Added to this, climate change has resulted in more localised, extreme events and sudden pest and disease outbreaks; these changes are already resulting in greater unpredictability of production between years and seasons, and require rapid and adaptable management responses (PAR *et al.* 2011). As such, many agronomists have looked to biotechnology – the exploitation of biological processes in production and development – to solve issues of sustainable production and resilience, such as pests and droughts.

A recent meta-analysis has found that GM technology adoption has, on average, reduced chemical pesticide use by 37 per cent, increased crop yields by 22 per cent, and increased farmer profits by 68 per cent (Klümper *et al.* 2014). It is thought that GM crop varieties are advantageous in certain situations, such as when pesticide or herbicide resistance is problematic (Klümper *et al.* 2014), but research has largely been limited to plants with significant commercial value (Turral *et al.* 2011). In addition, while biotechnology could be used to develop drought tolerance, it has had limited impact to date (Turral *et al.* 2011). In fact, using existing biodiversity and traditional breeding methods, rather that GM technology, may be a more appropriate way forward (Jacobsen *et al.* 2013).

Precision agriculture comprises a set of technologies, such as sensors, information systems and enhanced machinery, that optimise production by accounting for variability and uncertainties within agricultural systems. Adapting production inputs through informed management allows better use of resources to maintain the quality of the environment, while improving the sustainability of the food supply (Gebbers *et al.* 2010).

Soil conservation.

Soil provides both nutrients and physical support for the growth of plants for consumption. It also retains, provides and purifies water (FAO *et al.* 2015). While there is cause for optimism in some regions, the overwhelming conclusion from regional assessments is that the majority of the world's soil resources are in fair to very poor condition. Globally, the biggest threats to soil function are soil erosion, loss of soil organic matter and nutrient imbalance, which are going to worsen without concerted efforts in soil conservation. Compelling evidence exists that humanity is close to the global limits for total fixation of nitrogen, and regional limits for phosphorus use. Action must be taken to stabilise and reduce global nitrogen and phosphorous fertiliser use, while still allowing for increased fertiliser use in regions of nutrient deficiency. Increasing the efficiency of nitrogen and phosphorous use by plants is a key requirement in achieving this goal (FAO *et al.* 2015).

Agroforestry

Agroforestry – the inclusion of woody perennials within farming systems – is both a traditional land-use approach used by subsistence farmers throughout the tropics, and a livelihood option promoted by international development efforts. Agroforestry systems range from livestock and pastoral systems, to home gardens, alley intercropping, and biomass plantations; such systems have a wide diversity of biophysical conditions and socioecological characteristics. When defined as more than 10 per cent tree cover on agricultural land, agroforestry accounts for 46 per cent of agricultural land globally (Zomer *et al.* 2009).

Urban agriculture

There is general agreement that urban agriculture is important for local food production, especially in the global south. It has a role in regulating green and blue water flows, organic waste flows, and pollination, and has important sociocultural values, including an improved quality of city life and increased local community capacity (Orsini *et al.* 2013; Aerts *et al.* 2016). In low-income countries, urban agriculture favours social improvement and household income, and increases food security and gender equality (Global Goal 5) (Orsini *et al.* 2013; Poulsen *et al.* 2015; Aerts *et al.* 2016). There is evidence that urban agriculture may also improve human health because of dietary changes in certain social classes, but these are potentially confounded by environmental pollution in the city. Quantitative evidence is limited, but available data suggest that the impact of urban agriculture has little impact on overall food productivity or total greenhouse gas emissions (Aerts *et al.* 2016).

1.3.4 Knowledge and research gaps

Further research and investigation is needed in the following areas:

Management and governance

- Policies subsidising the use of fertilisers and pesticides in developing countries (Turral *et al.* 2011).
- Global food loss and waste (FAO 2011b).

- Emission reductions and other ecosystem services of urban agriculture (through life cycle assessments) (Aerts *et al.* 2016).
- Urban agriculture and food security, including the impacts of urban sprawl and the loss of peri-urban farmland, pollution to/from urban ecosystems, and the support of appropriate institutions (Mok *et al.* 2014).
- Agricultural water-use, including high-resolution mapping of soils and groundwater, adaptation of cropping systems, and practical forecasting of droughts and floods (FAO 2011c).
- Agricultural policy incentives that decrease the exposure and vulnerability of agricultural systems to droughts and floods (OECD 2016b).
- Water quality issues due to agricultural pollution, including compliance with existing water quality regulations, Polluter-Pays-Principles, and the cost effectiveness and spatial targeting of policies (OECD 2012b).
- Economic and market instruments are needed to evaluate externalities of agriculture, as started by The Economics of Ecosystems and Biodiversity (TEEB): Agriculture and Food. Evaluations also need to occur on programmes such as payments for ecosystem services (PES).

Food provisioning and biodiversity

- Data on wild pollinator populations to inform management strategies (Goulson *et al.* 2015).
- The impacts of neonicotinoids on groups of flower visitors, such as solitary bees, butterflies, moths, flies and wasps (Dicks *et al.* 2013).
- The exploitation of wildlife (Joppa *et al.* 2016); wild meat and wildlife consumption and their role in livelihoods, including the dependence of different sectors of society on wild meat, its sustainability, and interventions (Milner-Gulland *et al.* 2003); and local, national and international mechanisms and drivers of the wild meat trade (Milner-Gulland *et al.* 2003; Nasi *et al.* 2008).
- Impacts of using insects as a food source, including the conservation of insects, zoonotic diseases, toxicity, and microbial and socioeconomic impacts (van Huis *et al.* 2013)
- Soil maps and forecasting soil change (FAO *et al.* 2015).
- Rational approaches for the environmental risk assessment of non-native control agents in the wider application of biological control (Bale *et al.* 2008); (Cock *et al.* 2016).

Nutrition and food security

- Indicators of nutritional status and its determinants and the disaggregation of data for analyses related to inequities (WHO 2013).
- The nutrition, food security, governance and gender variables in established and emerging informal settlements (Mohiddin *et al.* 2012).
- Metrics for diet quality and the food system (GloPan 2016).

1.3.5 Overview of networks and funding

The Food and Agriculture Organization of the United Nations (FAO) is the main global network on food, it has 194 Member States and a budget of USD 2.6 billion for 2016/17. The majority (61 per cent) of its funding is raised through voluntary support; the remainder from contributions by member countries. Other major international partnerships include the UNEP's Global Partnership on Nutrient Management (2012). An example of a global expert network is The Global Panel on Agriculture and Food Systems for Nutrition, which is an independent group of experts committed to tackling global challenges in food and nutrition security; it is jointly funded by UKaid and the Bill and Melinda Gates Foundation.

The Global Environment Facility (GEF) launched a new programme entitled Fostering Sustainability and Resilience for Food Security in Sub-Saharan Africa, investing USD 900 million over five years from 2015. The GEF also works on issues to address the water, food, energy and ecosystem nexus. An example of how this funding is employed includes the Sahel and West Africa Programme (SAWAP) on land management, productivity and climate resilience.

The Economics of Ecosystems and Biodiversity (TEEB): Agriculture and Food study brings together a network of scientists, economists, policymakers, business leaders and farmers' organisations to undertake economic evaluations of whole agricultural systems.

The Global Environmental Change and Food Systems (GECAFS) was a 10-year (2001-2011) comprehensive programme by IGBP, IHDP and WCRP of international, interdisciplinary research focused on understanding the links between food security and global environmental change.

PROteINSECT is an EU research project that evaluates the use of insects as a sustainable source of protein.

1.4 GLOBAL GOAL 3: ENSURE HEALTHY LIVES AND PROMOTE WELL-BEING FOR ALL AT ALL AGES

1.4.1 Summary of Global Goal

Global Goal 3 seeks to ensure health and well-being for all, at every stage of life. The Goal addresses all major health priorities, including reproductive, maternal and child health; mental health; communicable, non-communicable and environmental diseases; universal health coverage; and access for all to safe, effective, quality and affordable medicines and vaccines. It also calls for more research and development, increased financing, and strengthened capacity of all countries in health-risk reduction and management (UNECOSOC 2016b). The aims of this Goal are mirrored in other multilateral environmental agreements, such as Aichi Biodiversity Target 14 of the Convention of Biological Diversity (CBD) (CBD 2010b). This stipulates that ecosystems that provide essential ecosystem services, such as those that contribute to health, are to be restored and safeguarded by 2020.

1.4.2 Overview of main environment-human interactions

In this report, we use the World Health Organisation's (WHO) definition of health: "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". The environment provides a suite of health benefits to humans (UNEP 2016h). Humans benefit from resources provided by the environment that sustain human life, such as food (Global Goal 2), medicine (directly from harvesting medicinal species, or through the use of nature in medical research and drug discovery), and water (Global Goal 6). The environment also has positive impacts on human mental health, well-being and culture. In addition, we benefit from ecosystem services that provide clean air and water, pest and disease regulation, and disaster-risk reduction. The Millennium Ecosystem Assessment framework highlights health as one of the four constituents of well-being which have linkages with ecosystem services, and that these linkages are strong (MA 2005). It also noted that public health costs associated with damage to ecosystem services can be substantial (MA 2005).

Despite the wide range of positive interactions between the environment and human health, the environment also carries a number of risks. Negative health impacts associated with the environment can be grouped into three broad categories: (i) 'direct' impacts include natural disasters and hazards like floods, earthquakes, heatwaves and exposure to ultraviolet radiation (Global Goal 1 and 13); (ii) 'ecosystem mediated' health impacts include malnutrition, altered infectious diseases, zoonotic diseases, poor mental health and depletion of natural resources for medicine (Global Goals 2, 14 and 15); and (iii) 'indirect' impacts include the consequences of livelihood loss (Global Goal 8), population displacement, conflict (Global Goal 16). The environment can also negatively impact human health though climate change (Global Goal 13), and the effects of pollution from energy (Global Goal 7), industry and production (Global Goal 9 and 12), as well as agriculture (Global Goals 2 and 12). It is estimated that 23 per cent of all deaths are attributable to the environment (Prüss-Üstün *et al.* 2016).

1.4.3 Synthesis of developments in research, innovations and policies

Communicable and parasitic diseases and the environment

Communicable diseases (also known as infectious or transmissible diseases) are those that result from the infection, presence and growth of pathogenic biological agents. They are transmissible by direct (e.g. contact with affected individual or their discharges) or indirect means (e.g. a vector), and include diseases such as HIV, Ebola and measles. Globally, our interactions with the environment drive changes in Emerging Infectious Diseases (EIDs); for instance, the leading driver of EIDs from wildlife is land-use change (Global Goal 15), followed by human susceptibility to infection, and the agricultural industry (Global Goal 2). Other factors driving EIDs include the propensity for international travel, war, demography, and hunting for wild meat (UNEP 2016h). Given their widespread nature, EIDs are a significant burden to public health, and the global economy (Jones *et al.* 2008). Furthermore, an analysis of 335 EID events between 1940 and 2004 showed an increase in the number of events over time. These events were largely zoonoses (60.3 per cent), of which, 71.8 per cent originated from wildlife (for instance, Ebola). In total, 54.3 per cent of the 335 EID events analysed were caused by bacteria or rickettsia, which reflects a large number of drug-resistant microbes in the study (Jones *et al.* 2008).

Humans, animals and the environment itself serve as reservoirs and sources of microorganisms that are hazardous to public health, such as bacteria, viruses and parasites. Waterborne pathogens in surface waterbodies are typically of faecal origin, introduced by humans and wildlife (WHO 2016). Many waterborne diseases can also be linked to sanitation issues (Global Goal 6), arising from a

lack in availability of clean water and adequate sanitation mechanisms. Health effects that arise from poor water quality include dysentery, giardia, diarrhoea and cholera (Fewtrell *et al.* 2005). In a review of water, sanitation and hygiene interventions to reduce diarrhoea, it was found that the interventions were largely successful, but that there is not enough available data to disentangle the reasons why they were successful (Fewtrell *et al.* 2005).

Another disease mediated by human-environment interactions is malaria. Globally, malaria cases fell from 262 million in 2000, to 214 million in 2015; in 2015, most cases (88 per cent) were estimated to have occurred in the WHO African Region (WHO 2015). The number of deaths from malaria also declined globally by 48 per cent in the same period. In 2000, 13 countries had fewer than 1,000 malaria cases, in comparison to 33 countries in 2015; this indicates that countries have been actively working to eliminate malaria (WHO 2015). Current policies and technologies used to address malaria include: making sure the population has access to insect-treated mosquito nets (ITNs); ensuring people sleep under ITNs; the use of indoor residual spraying; chemoprevention treatment for pregnant women and children; diagnostic testing; and treatment. Insecticide and antimalarial drug resistance remains a challenge (WHO 2015).

Urban environments offer favourable grounds for the spread of infectious diseases, especially in areas of high population density with low resources, such as informal settlements. Increased international travel and migration have also resulted in cities becoming important hubs for the transmission of infectious diseases (Global Goal 11). In addition, rapid urbanisation can introduce diseases into cities that are mostly prevalent in remote, rural areas. For instance, schistosomiasis has established itself in urban areas, most probably through infected migrants arriving in many Sub-Saharan African cities (WHO *et al.* 2016). Unless appropriate measures are taken to address drivers of unsustainable cities, these health risks are likely to increase given that the percentage of the world's population living in urban areas is projected to increase (Global Goal 11).

Non-communicable diseases and the environment

Non-communicable diseases (NCDs) are those that are not infectious or transmissible among people, and include diseases like cancer, diabetes and asthma. They cover a broad range of avoidable and unavoidable human health conditions, including some influenced by external factors, such as sunlight, nutrition, pollution and lifestyle choices.

Malnutrition affects people worldwide, with both undernutrition and micronutrient deficiencies, as well as, excessive weight and obesity being major health issues. Undernutrition and micronutrient deficiencies are closely related issues of access to food supplies and hunger (Global Goal 2). Lifestyle and consumption choices may also lead to undernutrition and obesity (recent estimates suggest 2 billion people worldwide are overweight or obese), and are major issues for food security (Global Goal 2) and sustainability (Romanelli *et al.* 2015). Other NCDs that may be impacted by such lifestyle and consumption choices include cardiovascular diseases, cancers, diabetes and chronic respiratory diseases. Together, they represent the world's leading causes of death, accounting for 36 million people globally in 2008 – 63 per cent of all deaths globally (WHO 2010b). Urban lifestyle is considered to be a driving factor for the increase in the burden of NCDs (WHO *et al.* 2016).

The natural environment can also supplement and modulate human microbiota and the benefits they gain from it, such as the regulation of the immune system. Socioeconomic status, diet, and living conditions are all likely to affect the diversity of human microbiota. Studies show that, increases in NCDs, such chronic inflammatory disorders, that occur as societies become urbanised and westernised are partly attributable to defective immunoregulation, in which the gut microbiota play a major role (Romanelli *et al.* 2015).

Mental and physiological health, and well-being

Mental health issues are consistently ranked in the top ten non-fatal threats across the world (UNEP 2016h); depression, for example, is expected to have the second leading impact on Disability Life Years (DALYs) by 2020 (Kessler *et al.* 2005). Yet the positive effects of nature on human mental health are plentiful and well documented (Global Goal 15). Recent reviews of the connections between nature and human health found that exposure to nature increased well-being, self-esteem and prosocial behavior, and general health of children, while decreasing stress, depression, anger, anxiety, blood pressure, diabetes, illness and attention deficit hyperactivity disorder (ADHD) in children (Fuller *et al.* 2007; Sandifer *et al.* 2015). The review also demonstrated that exposure to nature had positive effects on cognitive function and ability, reducing mental fatigue, and improving academic performance and productivity, as well as positive social effects, such as increased interactions with people, reduced aggression and increased inspiration (Sandifer *et al.* 2015). Since, an increasing proportion of the world's population live in urban areas where contact with nature is limited, improving urban design to include access to

greenspace is crucial for improved mental health and well-being.

Hazardous chemicals, pollution and contamination

Exposure to poor quality air caused by pollution is the leading environmental risk to health, accounting for 7 million deaths annually (UNEP 2016h). Air pollution is one of the main environmental risk factors associated with asthma, cardiovascular diseases, lower respiratory infections, chronic obstructive pulmonary disease, cancer and neonatal conditions (UNEP 2016h). Ineffective waste management (Global Goals 6, 9, 11 and 12) also causes major health impacts. Sixty-four million people are affected by the 50 biggest active dumpsites in the world. In Mexico, the average life expectancy of waste pickers (39) is much lower than the rest of the population (69) (UNEP 2016h).

In 2013, 3.3 million cases of human poisonings were recorded. Annually, it has been estimated that the inappropriate use of, and exposure to, pesticides (Global Goal 2) causes acute poisoning in 25 million people in developing countries (Romanelli *et al.* 2015); a large proportion of those affected are impoverished rural workers. The agricultural sector uses 70 per cent of all global antibiotics; overuse of which is known to contribute to the evolution of resistant strains of microbes, which may threaten human health. Metals-based pesticides and heavy metals (such as lead and cadmium) contaminate agricultural soils through the direct application of sewage-sludge fertilisers. Exposure to heavy metals such as lead and mercury have has been linked to mental and other health difficulties in children, including seizures, delayed development, and loss of vision and hearing. Asia and the Pacific are estimated to be responsible for the emissions of 50 per cent of anthropogenic mercury worldwide, largely due to coal-burning power plants, boilers and small-scale mining (UNEP 2016h). Indeed, mining and other extractive industries have other implications for health, too, largely affecting people in the tropics and developing countries (UNEP 2016h).

Micro- and nano- material pollution is an emerging issue for human health. In marine ecosystems, micro- and nano-plastics sink to the ocean floor where they are not exposed to the sunshine required for biodegradation (Global Goal 14). Negative impacts to human health from micro- and nano- material are currently not fully understood. However, impacts of microplastics typically results from the ingestion of marine foodstuffs that have incorporated such particles, ingestion of contaminated water or direct inhalation of contaminated air (UNEP 2016h).

Interactions with environmental change and natural disasters

Environmental changes endanger the lives of millions of people, largely through five key interactions: water scarcity (Global Goal 6), food scarcity (Global Goal 2), exposure to infectious diseases, population displacement, and natural disasters (Global Goals 1 and 13). Currently, all types of anthropogenic environmental change are accelerating, including climate change (Global Goal 13), land-use and land-cover change (Global Goal 2 and 15), and ecosystem degradation (Global Goal 15) (Myers *et al.* 2009). These changes bring with them increasing vulnerabilities for large groups of people worldwide (Global Goals 1 and 13). The scale of deaths due to environmental degradation is estimated to about 200 times that of the premature deaths that occur in conflicts annually (UNEP 2016h). Climate change can impact human health in both direct and indirect ways. Direct effects of climate change include increased storms, floods, droughts and other extreme weather events. In turn, these may indirectly affect water quality, air pollution, land use and ecological change, as well as aspects of social dynamics. Health impacts from both direct and indirect effects include mental illness, undernutrition, allergies, cardiovascular and respiratory diseases, infectious diseases, injuries, and poisoning (Watts *et al.* 2015).

1.4.4 Knowledge and research gaps

Overall, current studies on ecosystem services lack information on the relationship between the biological characteristics of the environment and their direct effects on human health (Sandifer *et al.* 2015). More specific knowledge and research gaps relating to health and the environment include:

Population health and resilience

- Global, reliable, fine-scaled and georeferenced data on population health, environmental conditions, resource availability, quality of infrastructure, and the host of factors that determine vulnerability over long periods of time (Myers *et al.* 2009; Sandifer *et al.* 2015).
- The links between biodiversity, dietary diversity, and health, and the relationship between dietary biodiversity and the human microbiome diversity (Romanelli *et al.* 2015).
- The potential environmental, health, occupational and general safety hazards of nanotechnology; including nanotoxicity and methods for assessing and managing the risks inherent in the use of such materials (EEA 2010).

Infectious and parasitic diseases and the environment

- The relationships between biodiversity (species diversity, disturbance and human-

wildlife contacts), biodiversity change and infectious diseases, and the implications for spatial planning (Romanelli *et al.* 2015).
- Physical health and prevalence of disease in relation to nature exposure (Sandifer *et al.* 2015), as well as surveillance and research in low-latitude areas which are at substantial risk from wildlife zoonotic and vector-borne diseases (Jones *et al.* 2008).
- New tools and innovations to control neglected tropical diseases and disease vectors, and provide point-of-care diagnostic tests (WHO 2015).
- Understanding of the diversity of diseases, and their transmission patters, in different geographical settings, as well as, diagnostic tests in these settings (WHO 2015).
- In relation to malaria, specifically, innovation methods for rapidly providing services in order to expand access to interventions (Watts *et al.* 2015).
- Surveillance mechanisms to detect changing patterns of infectious disease, malnutrition and environmental disasters (Myers *et al.* 2009), especially for worrying trends in dengue in Africa (WHO 2015).

Mental health and well-being
- The mechanisms by which nature exposure affects mental health outcomes and the aspects of the human experience of nature that is calming and restorative, including whether structural heterogeneity of diverse habitats and diversity of species specifically plays a role (Sandifer *et al.* 2015).

Health implications from environmental change
- The health impacts of environmental change including the impacts of: different approaches to reducing global carbon dioxide emissions versus continuing business as usual; the widespread adoption of improved agricultural techniques; and altered management of coastal zones (Myers *et al.* 2009).
- Scientific evaluation of the health benefits of climate change adaptation (Watts *et al.* 2015).
- The emerging concern around consumption or inhalation of micro- and nano- materials through contaminated marine foodstuffs or water (UNEP 2016h).

1.4.5 Overview of networks and funding

A large number of health related networks exist throughout the world. In terms of global health policy and action, WHO provides leadership on matters critical to health and engages in partnerships where joint action is needed. Health research is undertaken by a broad range of actors and networks including governments, universities and private companies (for example, pharmaceutical companies). Cochrane is one of the leading global independent networks of researchers, professionals, patients, and carers, in relation to all types of health research. There are also more specific networks related to the environment and health including the WHO Health and Environment Linkages (HELI) network, the Geneva Environment Network (GEN) (coordinated by the United Nations Environment Programme and supported by the Swiss Federal Office for the Environment) and the Health and Environment Alliance (HEAL).

The funding for health related research comes from a broad range of sources including international organisations, national governments, private companies and foundations. A number of new funding initiatives have been established in recognition of the critical need to address data, for example, the World Bank and WHO, with input from several agencies and countries, have developed a *Global Civil Registration and Vital Statistics Scaling Up Investment Plan*. Foundations funding has also supported data issues, as well as, many other topics. For example, Bloomberg Philanthropies funds health work including, Data for Health, a USD 100 million initiative that will enable 20 low- and middle-income countries (LMICs) to vastly improve public health data collection and its use. The Bill and Melinda Gates Foundation has a global health division that aims to harness advances in science and technology to save lives in developing countries. Its recent work includes supporting the WHO to estimate the burden of dengue in selected countries (WHO 2015).

1.5 GLOBAL GOAL 4: ENSURE INCLUSIVE AND EQUITABLE QUALITY EDUCATION AND PROMOTE LIFELONG LEARNING OPPORTUNITIES FOR ALL

1.5.1 Summary of Global Goal

Global Goal 4 commits to providing inclusive and equitable quality education at all levels, and to promoting lifelong learning opportunities to all. Throughout its targets, it lays particular emphasis on the need for gender equality in education at all ages. Goal 4 also aims to "ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles". Indeed, the important role of education in sustainable development has long been recognised in the global policy context. Improving and reorienting

education is one of the goals of Agenda 21, which was adopted in 1992 and has a chapter dedicated to Promoting Education, Public Awareness and Training (UNESCO 2014b). The United Nations Decade of Education for Sustainable Development (UNDESD) (2005-2014), which was declared following the World Summit on Sustainable Development in 2002, has also reoriented education towards sustainable development. Furthermore, education forms part of the three Rio conventions (i.e. United Nations Framework Convention on Climate Change [UNFCCC], Convention on Biological Diversity [CBD], United Nations Convention to Combat Desertification [UNCCD]); and in *The Future We Want* (the outcome document of the UN Conference on Sustainable Development [Rio+20] in 2012), member states agreed to promoting and integrating education for sustainable development beyond the UNDESD (UNESCO 2014b).

1.5.2 Overview of main environment-human interactions

While education can be considered as the key to accelerating progress towards reaching all 17 Global Goals (UNESCO 2014a), Global Goal 4 explicitly looks at the links between the environment and education in relation to sustainable development. Education functions as the bedrock of sustainable development because it contributes to all three dimensions of sustainable development – economic, social and environmental. It achieves this by "shaping personal and collective identities, promoting critical social capital and cohesiveness, and [advocating] responsible citizenship based on principles of respect for life, human dignity and cultural diversity" (UNDESA 2014).

Achieving sustainable development requires changing the way people think and act; education can play a crucial role in bringing about such change (UNESCO 2014b). Therefore, education is critical in shaping the way people use, and behave towards, the environment. In 2005, the Millennium Ecosystem Assessment (MA) recognised this critical relationship, noting that education "provides tremendous social benefits that can help address many drivers of ecosystem degradation". Furthermore, it noted the need for improved education and communication in order to achieve both the objectives of the environmental conventions, and the sustainable management of natural resources in general. In addition to the inverse relationship, in which ecosystems and their components and processes also provide the basis for formal and informal education in many societies (MA 2005), the critical link between education and the environment lies in the potential of education to shape human behaviour towards the environment. However, this relationship is not always straight forward and varies in different contexts.

1.5.3 Synthesis of developments in research, innovations and policies

The role of education in shaping the way we behave towards the environment

Education has been documented as influencing the way humans interact with the environment in various ways; these are described here, along with a number of possible limitations to the cause-effect view of these relationships.

Increasing environmental awareness and concern.

One of the crucial roles education can play in sustainable development is in improving people's understanding of the science underlying environmental issues, including climate change (Global Goal 13) (UNESCO 2014a). In turn, such understanding can increase the concern people express for the environment. For example, the 2005 to 2008 World Values Survey, which was conducted in 47 countries, showed that the higher the level of education a person had achieved, the greater their concern for the environment was (UNESCO 2014a). Additionally, the 2010 to 2012 World Values Survey revealed that, when forced to choose between protecting the environment versus boosting the economy, respondents with secondary level education favoured protecting the environment more than those with lower levels of education (UNESCO 2014a).

Changing behaviour by increasing citizens' engagement.

Higher levels of education are not only said to increase people's concern for the environment, but also to lead them to engaging in activism that promotes and supports political decisions to protect the environment (UNESCO 2014a). For example, in nearly all participating countries in the 2010 International Social Survey Programme, respondents with higher levels of education were more likely to have signed a petition, given money, or taken part in a protest or demonstration, in relation to the environment, over the previous five years (UNESCO 2014a). When researching public support for environmental protection among individuals from 50 nations, Gelissen (2007) found that higher levels of educational attainment are positively related to environmental supportiveness. Pisano and Lubell (2015) also noted that, across nations, environmental behaviours are positively related to education level, environmental knowledge and pro-environmental attitudes.

Improving the management of natural resources in the face of change.

Education is key to providing information to managers and users of natural resources in order for them to effectively manage these resources. In particular, in low-income countries, where the majority of people depend on agriculture for income rather than wages from other sectors, education can help to increase farm profits (Global Goal 2). Indeed, educated farmers have been shown to more accurately interpret and respond to new information (such as better use of fertilisers, adopting soil conservation and erosion-control measures, and introducing new seed varieties) than farmers without education (UNESCO 2014a). Thus, education also plays an important role in how people deal with changing resources. In semi-arid areas of China, for example, educated farmers are more likely to use rainwater harvesting and supplementary irrigation technology to alleviate water shortages (Global Goal 6) (UNESCO 2014a). Additionally, in the face of climate change, higher levels of education have been associated with farmers implementing more adaptation measures (UNESCO 2014a).

Increasing education is not a panacea.

Although many positive links between education and improved human behaviour towards the environment have been documented, an increase in knowledge does not automatically lead to increased concern for, and action towards, the environment. In fact, there is a growing body of practice-focused literature that points to a lack of success of many 'ABC' (attitude, behaviour, choice) approaches, according to which educating the public about environmental problems will cause them to change their behaviours (Walker in press). Globally, policy regarding education for sustainable development (ESD) has mainly adopted ABC logic; such policy makes children, in particular, the prime targets for environmental education initiatives, considering them to be "learners and conduits of knowledge" and envisioning them as acting "as a form of 'embodied power' […] carrying environmental concerns from educational settings into other spaces of their everyday lives and influencing the practices of those around them" (Walker in press). However, a number of complex issues influence the ability of ESD to support children's involvement in behaviour change within their household and the wider community. Generational positioning, family members' interdependent agency, and structural constraints encountered by families in acting on environmental knowledge all affect the effectiveness of ESD (Walker in press). Focusing research on families as units of study can help to clarify such interactions, providing a "nuanced understanding of the tensions, conflicts and contradictory practices that can act as barriers" to improved human behaviour towards the environment (Boddy *et al.* in press). Another area of research that has revealed limits to the ABC logic applied to environmental education relates to affluence and lifestyle habits. People who are well educated often have lifestyles that burden the environment; for example, in the world's fastest growing cities, those that are more educated are more likely to possess private vehicles and less likely to stop using them despite the negative effects of traffic congestion and air pollution on the environment (Global Goal 11) (UNESCO 2014a).

The position of education for sustainable development (ESD) today

Recognising the importance of ESD, the UNDESD was launched in 2005 with the aim of "integrating the principles and practices of sustainable development into all aspects of education and learning, to encourage changes in knowledge, values and attitudes with the vision of enabling a more sustainable and just society for all" (Buckler *et al.* 2014). The final UNDESD *Global Monitoring and Evaluation Report* (Buckler *et al.* 2014) provides a detailed assessment of the progress made towards embedding ESD into education systems and into sustainable development efforts. Overall, the report shows that one of the most notable accomplishments of the UNDESD is that the profile of ESD has increased in national policies and agreements. In addition to such policy advances, a diverse range of stakeholders, including individuals, schools, institutions of higher education, community-based organisations, international non-governmental organisations (NGOs) and private sector organisations, have joined the ESD effort (Buckler *et al.* 2014). Throughout the decade, the non-formal education sector (such as NGOs and educational organisations) was one of the quickest sectors to adjust their programmes in response to the initiative; this was followed by institutions of higher education in the formal education sector (McKeown 2015). The adoption of ESD into primary and secondary schooling was slower; towards the end of the decade, however, ESD's contribution to a quality education became general discourse throughout most of the formal education sector (McKeown 2015).

Ten key findings and trends were reported at the end of the UNDESD (Buckler *et al.* 2014):

- Education systems are addressing sustainability issues;
- Sustainable development agendas and education agendas are converging;
- Political leadership has proven instrumental;
- Multi-stakeholder partnerships are particularly effective;

- Local commitments are growing;
- Whole-institution approaches help promote ESD;
- ESD facilitates interactive, learner-driven pedagogies;
- ESD is being integrated into formal education;
- Non-formal and informal ESD is increasing;
- Technical and vocational education and training advances sustainable development.

To build on these achievements, as well as many lessons learned, UNESCO launched the Global Action Programme (GAP) for ESD in November 2014 as a follow-on programme to the UNDESD. The overall goal of GAP is to generate and scale-up action at all levels, and in all areas, of education and learning in order to accelerate progress towards sustainable development, particularly in relation to the post-2015 agenda (UNESCO 2014b).

1.5.4 Knowledge and research gaps

In the context of improving education, it is critical to ensure that, as knowledge gaps are filled, new understandings are passed on to the educators. If educators are not equipped with the most recent knowledge on education for sustainable development and the environment, little progress can be made. There is already a lack in the capacity of current educators and early childhood primary caregivers to be able to incorporate ESD into their teaching and care-giving activities (Buckler *et al.* 2014). Therefore, there is a strong need to fill the gap between researchers and implementers.

The important knowledge and research gaps that exist include the following:

Evidence base for best practice

- Research, innovation, monitoring and evaluation to develop and demonstrate the effectiveness of ESD good practices (identified as a need by Member States and other stakeholders of the UNDESD) (Buckler *et al.* 2014).
- Evidence base on the links between raising awareness and behavioural and lifestyle changes, to enable identification of the key elements necessary to produce change through education (Buckler *et al.* 2014). This includes differences between the global North and South, so that northern-centric ideals of environmentalism are not imposed on all, and necessary changes are brought about in a culturally sensitive manner (Boddy *et al.* in press).

Understanding teaching and learning

- New forms of teaching and learning, as well as the kinds of curricula, learning environments and school-community relationships that are important for: fostering and promoting competencies crucial to strengthening sustainable development (such as understanding complex interactions); identifying connections and interdependencies; and critically questioning systems, policies and routines that appear unsustainable (Leal Filho *et al.* 2015).
- Research on the process of multi-stakeholder social learning, including development of innovative methodologies to capture the learning taking place at the various levels, and to improve understanding of how this learning is contributing to sustainability (Buckler *et al.* 2014).

ESD in early childhood education

- Empirical work on the teaching and learning of ESD in early childhood education, moving beyond current theoretical research (Hedefalk *et al.* 2015).

Operational mechanics of networking and partnerships in ESD

- The practice of networking within ESD to transfer lessons from work on networking within the in sustainable development policy arena, and ensure that the full benefits of collaboration for sustainability are being achieved (Buckler *et al.* 2014).

1.5.5 Overview of networks and funding

The UNDESD, and its follow-on initiative, GAP (see previous section), are the major platforms for advocating the inclusion of sustainable development in formal and informal education. Based on lessons learned from the UNDESD, GAP has identified five priority areas of work (advancing policy; transforming learning and training environments; building capacities of educators and trainers; empowering and mobilizing youth; accelerating sustainable solutions at local level) and established partner networks (including 87 members to date) around each priority in order to drive the implementation of ESD and to serve as a global community. Such UNESCO initiatives have received active financial support from the Japanese government's Funds-in-Trust.

The UN Environment Programme's (UNEP) Environmental Education and Training Unit (EETU) also works on the links between the environment and education, serving as a focal point for implementation of GAP. EETU's programmes, projects, initiatives and activities are organised around three pillars, education, training and networking; there is a specific focus on higher education through the Global Universities Partnership on Environment and Sustainability (GUPES). The UN University, headquartered in Japan, is another UN-driven educational effort,

offering postgraduate teaching, such as environmental courses. Additionally, countless NGOs around the world integrate environmental education components throughout their work, including conservation NGOs like WWF.

Overall, between 2011 and 2013, official development assistance for educational scholarships (not limited to ESD) amounted to around USD 1.1 billion annually. It totalled USD 1.2 billion in 2014, with Australia, France and Japan being the largest contributors.

1.6 GLOBAL GOAL 5: ACHIEVE GENDER EQUALITY AND EMPOWER ALL WOMEN AND GIRLS

1.6.1 Summary of Global Goal

Gender equality plays a critical role in all of the Global Goals, and many of their targets specifically recognise women's equality and empowerment as both the objective, as well as part of the solution. Global Goal 5, however, is a stand-alone Goal focusing on gender, and is dedicated to achieving these ends. Specifically, it calls to end discrimination and gender-based violence; eliminate child marriage; eradicate female genital mutilation; ensure access to sexual and reproductive health care; protect women and girls' reproductive rights; eliminate gender disparities in education; expand women's economic opportunities; recognise women's rights to resources; and reduce the burdens of unpaid care work on women and girls. Global Goal 5 distinguishes itself from the minimal commitments on gender outlined in the preceding Millennium Development Goals (MDGs). This is an important step as gender equality remains a persistent challenge for countries worldwide, and the lack of such equality is a major obstacle to sustainable development (UNECOSOC 2016b).

The importance of gender equality in achieving sustainable development has been increasingly recognised by international commitments, including environmental agreements (UNEP 2016e). Starting in 1979, the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW) was adopted by the United Nations (UN) General Assembly to provide for the advancement of non-discrimination and rights through the obligations of governments to promote, protect and fulfil the equal rights of women and men. In 1995, the Beijing Declaration and Platform for Action called for action to build upon the progress made at the UN Conference on Environment and Development (UNCED) in 1992; it also called for full and equal participation by women and men as agents and beneficiaries of sustainable development. The three Rio Conventions on biodiversity, desertification and climate change that resulted from UNCED address gender concerns in varying ways. For example, the Preamble to the Convention on Biological Diversity (CBD) recognises the vital role women play in the conservation and sustainable use of biodiversity. Most recently, the 2015 United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement recognises the intersection between climate change, gender equality, the empowerment of women and the realisation of women's rights.

1.6.2 Overview of main environment-human interactions

In 2005, the Millennium Ecosystem Assessment (MA) identified several important interlinkages between gender equality and ecosystem services. For example, it showed that changes in ecosystems typically yield benefits for some people, while exacting costs on others. Such costs include losing access to resources and livelihoods, or being affected by externalities associated with the change. Significant differences between the roles and rights of men and women in many societies lead to women having an increased vulnerability to such changes (MA 2005). Within many societies, the responsibility for routine care of the household often lies with women, even when they play important roles in agriculture (MA 2005). The MA (2005) noted that the degradation of ecosystem services, such as water quality and quantity, fuelwood, or agricultural and rangeland productivity, often results in increased labour demands on women. This can affect the whole household by diverting time from food preparation, child care, the education of children and other beneficial activities (MA 2005).

Today, gender inequality is still considered as being one of the most pervasive threats to sustainable development. As the Global Gender and Environment Outlook (GGEO) (UNEP 2016e) notes, it has negative impacts on access to, use of, and control over a wide range of resources. It also affects our ability to meet human rights obligations with respect to having a clean, safe, healthy and sustainable environment. The drivers of environmental change affect men and women in different ways. Whether environmental change is fast and acute, or slow and chronic, it has very different impacts on women and girls, and on men and boys (UNEP 2016e). Moreover, austerity measures and public spending cuts in recent years have exacerbated gender inequalities. Increasingly, the burden of ensuring the survival of individuals and households is shifting onto the shoulders of women and girls, adding to their

unpaid domestic and care work, and increasing their time poverty (UNEP 2016e). Nonetheless, as documented in the UN Women report, *Gender Equality and Sustainable Development* (UN Women 2014), women are not just victims of environmental change, but are often agents, leading the way in developing solutions to environmental challenges. This requires women to have rights and decision-making power; otherwise, relying on women as 'sustainability saviours' in environmental projects may only add to their unpaid care burdens, and may have negative effects on gender equality (Leach 2015).

As stated in the GGEO (UNEP 2016e), the priority issues in the gender-environment nexus can be clustered as: rights to land, natural resources and biodiversity; access to food, energy, water and sanitation; climate change, sustainable consumption and production, and health. These clusters are discussed in the next section.

1.6.3 Synthesis of developments in research, innovations and policy

The GGEO (UNEP 2016e) provides the most recent global review and synthesis of information about the links between gender and the environment, and their importance for gender-sensitive policies and actions. This section summarises the relevant key findings from the GGEO and points to some additional, complementary publications.

Importance of gender and environment throughout the Global Goals

Despite having a stand-alone goal, it is intended that gender considerations are integrated throughout all the Global Goals in order to break away from traditional 'siloed' approaches. Similarly, environmental protection is meant to feature throughout all the Global Goals, so as to achieve integration. However, the gender-environment nexus has only recently been re-emphasised, following a gap in policy attention and research during the early 2000s. This has led to a lag in integration. Much environmental research and programming still works with undifferentiated notions of 'the household' or 'the community'. Although it is intended that both gender equality and environmental protection are thoroughly integrated throughout the Global Goals, only one of the strictly environmental goals actually mentions gender within its targets (Global Goal 13.b), and none of the gender-focused goals include specific links to the environment. This lack of integration underscores the need to transform thinking in order to respond adequately to environmental crises and build solutions that also consider gender equality.

Rights to land, natural resources and biodiversity

The GGEO found that secure land tenure is fundamental to women's economic, social and political empowerment, as well as to increased prosperity for their families and communities. Furthermore, it highlights that it is security of tenure, rather than ownership per se, which is critical. However, according to the Organisation for Economic Co-operation and Development's (OECD) *Social Institutions and Gender Index* (2014), women and men have equal rights to own, use and control land in only 37 per cent of the 160 countries analysed. Indeed, in more than half of the countries that do have laws guaranteeing women and men the same rights, customary, traditional and religious practices still prevent access for women. In particular, as the GGEO highlights, there is a well-documented gender gap in access to forest resources, with women often having less access to, and control over, forest land and resources than men (due to customary laws and social norms, for instance). The problem of unequal rights and access is being worsened by the increasing overexploitation of forests for commercial purposes, including land grabbing, logging and the illegal wildlife trade.

With respect to biodiversity, and in terms of agrobiodiversity, the GGEO notes that different roles are played by women and men. For example, women often take on roles as custodians, users and adapters of traditional knowledge, thus contributing to food security and the conservation of plants and seeds for ongoing and future production. In the coastal environment, 47 per cent of the fishing workforce is seen to be female when the whole fishing cycle is taken into account, even though fishing is frequently portrayed as a male domain. Furthermore, the GGEO notes that evidence suggests that fisheries management improves when women are actively involved.

The research reviewed by the GGEO shows that the participation of women in local institutions that govern the use of natural resources is critical for sustainable management. Indeed, the importance of women's participation in environmental decision- and policymaking (including for climate change) at all levels (and the persistent gender inequality therein) has been highlighted in several other publications, including: UN Women's *Gender Equality and Sustainable Development* (UN Women 2014), the *Environment and Gender Index* (EGI) (IUCN 2013), and the *Human Development Report 2011* (UNDP 2011).

Access to food, energy, water and sanitation

As the GGEO notes, women tend to be the primary energy, water and sanitation managers for their households and families in most developing

countries. Together with children, women often bear a disproportionate burden with respect to finding and fetching water and fuel. Additionally, in both rural and urban areas (especially in urban slums and low-income neighbourhoods), a lack of basic infrastructure, coupled with poor energy, water and sanitation services, leads to women experiencing time poverty and social and economic pressures.

The food and nutrition security of women and girls can also be disproportionately compromised because women assume primary responsibility for feeding their families and even their communities. Indeed, the GGEO highlights that, although women produce a significant proportion of food in the developing world (mainly through smallholder farming), they often remain worse fed and more undernourished than men and boys because of cultural and social norms. Recent trends in food security, and the role of gender equality therein, are reviewed by UN Women (UN Women 2014); in addition, this report also highlights the importance of land rights (see section above) in the context of improving food security. However, as the UN Women report shows, women cannot be treated as an undifferentiated group; cross-cutting differences of wealth, ethnicity, age and family status have important effects on their labour, rights and decision-making power. An understanding of such differences, and a focus on gender relations rather than just women and girls, is essential.

Climate change, sustainable consumption and production, and health

The GGEO recognises that the impacts of climate change amplify existing gender inequalities and jeopardise the well-being of all. Climate change and its related uncertainties put further pressure on already fragile, undervalued and precarious gender roles and responsibilities at community level, which affect the nature and extent of exposure, sensitivity and impacts. The gender-differentiated consequences of climate change can intensify the workloads and vulnerabilities of women who rely on agriculture and the use of natural resources for their livelihoods. Furthermore, climate- and disaster-related health risks, along with increased water and fuel scarcity, may add to women's unpaid care work. Indeed, the GGEO finds that women have differentiated vulnerabilities to climate change due to gendered labour and care roles, and social status; this is the case for both disaster response and everyday living. The gender-differentiated impacts of climate change, and other important linkages between gender issues and climate change (such as differentiated patterns of consumption and production, and the links between climate change, gender and health), are explored in recent publications, including: *Roots for the Future: the landscape and way forward on gender and climate* (Aguilar *et al.* 2015); *Powerful Synergies: gender equality, economic development and environmental sustainability* (UNDP 2012); *Gender Equality and Climate Change* (European Institute for Gender Equality 2012); *Gender Equality and Sustainable Development* (Leach 2015); and *Practicing Feminist Political Ecologies* (Harcourt *et al.* 2015).

Overall, almost all the available evidence shows that resource use, priorities and decisions are gender-differentiated within households (UNEP 2016e). Household-based, environmentally relevant decisions and behaviours are negotiated, often unequally, between women and men inside the household; such matters include water use, division of labour, energy-source choices and financial allocations for agricultural adaptation. Intra-household dynamics are important in terms of resources and their use, conservation and consumption, and the ways in which women and men may act as agents of change.

1.6.4 Knowledge and research gaps

Sex-disaggregated information and gender statistics

- One of the strongest messages emerging from the GGEO review of evidence on the gender-environment nexus is the crucial need for sex-disaggregated information in the environmental realm. Research and data collection need to 'lift the roof off the household' in order to move beyond simple gender binaries (male-female) and reveal intra-household gender relations, assets and roles in resource utilisation and decision-making.
- There is a strong need to improve our understanding in a systematic way about women's roles in natural resource management, conservation, sustainable use, climate and environmental resilience, and to explore why women's active participation and decision-making in these areas is important (Seemin Qayum, UN Women, pers. comm.). The value of qualitative information in such research should be recognised; and such information should be included in global datasets to create sex-disaggregated indicators that can effectively track the implementation of Global Goals (UNEP 2016e).
- While both gender equality and environmental considerations are meant to be integrated throughout the Global Goals, in order to be able to build our understanding of the gender-environment nexus, indicators used to monitor progress towards the 'environmental' Global Goals (for example, Goals 6, 7, 12, 13, 14, 15) will need to include sex-disaggregated information (Seemin Qayum, UN Women, pers. comm.).

Gender-sensitive environmental assessments

- There is a need to include gender in environmental assessment tools and safeguarding measures at national and international levels as these are often prerequisites for development plans and activities that, ultimately, impact on women (UNEP 2016e). This could be done by making gender impact assessments (GIAs) mandatory in public and private environmental reviews, and by permitting, licensing and planning activities. Alternatively, it might be achieved by conducting national-level 'state of gender and the environment' assessments, which would help to establish a baseline against which future changes and progress might be measured.

Case studies and syntheses of less-researched issues

- These include: gender-environment relations in urban and peri-urban settings (rather than rural ones, where most research has been conducted to date); the gendered effects of market-based environmental schemes (e.g. payments for ecosystem services [PES], reducing emissions from deforestation and forest degradation [REDD], etc.); and women's knowledge, agency and leadership in local innovations to meet environmental challenges.
- Beyond a male-female dichotomy, research is also needed on the ways in which gender interacts with other forms of difference and inequality (wealth, ethnicity, geography) in relation to environmental issues in order to understand precisely who is vulnerable and why.

Lack of sufficient long-term data

- The GGEO identifies this as a further impediment to gendered environmental assessments. Correlations between gender and the environment may only become evident over long time periods. In several cases, although there appear to be causal relationships between gender and the environment, available evidence and data are insufficient to demonstrate that these relationships exist.

1.6.5 Overview of networks and funding

A large number of institutions and organisations are actively working on gender-environment issues. Within the UN system, UN Women focus, among other things, on sustainable development and climate change, and put gender equality and sustainable development at the core of its most recent five-yearly *World Survey* report (UN Women, 2014). Additionally, gender lies within one of the United Nations Environment Programme's (UNEP) priority areas of work. Furthermore, many other high-level institutions, such as the Food and Agriculture Organization (FAO) and OECD, take gender issues into account throughout their environmental programmes.

There are also countless non-governmental organisations (NGOs) working on gender-environment linkages, ranging from global advocacy organisations, such as the Women's Environment and Development Organization, to conservation NGOs. The International Union for Conservation of Nature (IUCN) has emerged as an important player in the gender-environment realm, with its Global Gender Office and the launch of its Environment and Gender Information (EGI) platform. The latter aims to close information gaps at the nexus of gender equality and environmental sustainability by providing global data on gender and the environment.

In terms of trying to fill the vast gap in sex-disaggregated data, the United Nations Educational, Scientific and Cultural Organization's (UNESCO) World Water Assessment Programme (WWAP) launched a project in 2014 to develop and test sex-disaggregated indicators for the collection of global water, which involved developing a methodology and toolkit for almost 50 high-priority gender and water indicators. Furthermore, the World Bank, the FAO and World Health Organization (WHO) have all launched major efforts to collect gender-disaggregated data, some of it environment-related. The FAO's Gender and Land Rights Database (GLRD), for example, was launched in 2010 to highlight the major political, legal and cultural factors that influence the realisation of women's land rights throughout the world.

Current donors taking a particular interest in funding gender-environment initiatives include the Swedish government, who are supporting UNEP on gender integration, as well as the Dutch and Finnish governments, who fund gender-related projects as part of their work on addressing inequalities.

1.7 GLOBAL GOAL 6: ENSURE AVAILABILITY AND SUSTAINABLE MANAGEMENT OF WATER AND SANITATION FOR ALL

1.7.1 Summary of Global Goal

Water and sanitation are at the very core of sustainable development, critical to the survival of people and the planet. Global Goal 6 not only addresses the issues relating to drinking water, sanitation and hygiene, but also the quality and

sustainability of water resources worldwide (UNECOSOC 2016b).

Freshwater is a finite resource necessary for economic growth (Global Goal 8), agriculture (including forestry, fisheries and aquaculture) (Global Goals 2 and 14), political and social stability (Global Goal 16), functioning ecosystems (Global Goal 15), human health (Global Goal 3), and poverty eradication (Global Goal 1). Poor access to sources of safe drinking water, coupled with inadequate sanitation and hygiene, presents one of the most critical public health challenges across the globe (WEF 2015a; WHO 2016).

Efforts to improve the protection and management of transboundary surface waters are supported by the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (1992). The conservation and sustainable use of all wetlands is supported by the Ramsar Convention on Wetlands (1971). Aichi Biodiversity Target 11 of the Convention on Biological Diversity (CBD 2010b) aims to conserve at least 17 per cent of inland water ecosystems, and Target 14 aims to safeguard ecosystems that provide services (including water) by 2020.

1.7.2 Overview of main environment-human interactions

Water intricately links humans and the environment, and sustains human life (WHO 2016). It enables the production of food (Global Goal 2), manufactured goods (Global Goal 12), and energy (Global Goal 7), and is strongly linked to human culture and religion. The management of water can also help regulate the spread of disease (Global Goal 3) and natural hazards. In 2005, the Millennium Ecosystem Assessment (MA) already highlighted the importance and increasing pressures on freshwater ecosystem services (MA 2005).

The relationship between the environment and humans is not always beneficial. Climate change is changing water cycles, including the frequency and intensity of water related hazards such as floods and droughts that can threaten clean water supplies for humans (Global Goal 13). Humans also directly change the dynamics of the water cycle through the construction of dams for water storage, and through water withdrawals for industrial, agricultural or domestic purposes. The unsustainable use of water, and severe pollution of water sources, diminishes usable water supply and impacts on aquatic ecosystems (MA 2005). In 2005, the MA estimated that water scarcity was already a globally important and accelerating condition for 1–2 billion people worldwide and that the water requirements of aquatic ecosystems in the context of expanding human freshwater use results in competition for the same resources.

1.7.3 Synthesis of developments in research, innovations and policies

Adequate and equitable drinking water and sanitation

Great strides have been made to improve access to clean drinking water over the past 25 years; indeed, 2.6 billion people have gained access to improved drinking water sources since 1990. The Millennium Development Goal (MDG) target for drinking water, to halve the number without sustainable access to safe drinking water, was met in 2010, five years ahead of schedule (UNICEF 2015). Yet, to achieve the more ambitious, post-2015 Global Goals, much remains to be done, particularly to reduce inequalities across populations. In fact, 748 million people do not have access to improved drinking water, and around 1.8 billion people use faecally contaminated water sources for drinking (UN-WATER *et al.* 2014). Improved drinking water sources remain acutely lacking in rural areas and the least developed countries. Insecure water access is a major constraint on poverty reduction in rural areas of Sub-Saharan Africa (Faurés *et al.* 2008) (Global Goal 1). Future climate change is also projected to reduce water quality, posing risks to drinking water quality under conventional treatment procedures (Jiménez Cisneros *et al.* 2014).

Global sanitation coverage increased from 49 per cent in 1990 to 64 per cent in 2012. Despite this increase, there are still 2.5 billion people without improved sanitation, including one billion who have to resort to open defecation (UN, 2014a). There is a positive relationship between a country's Gross Domestic Product (GDP) and the proportion of wastewater treated; for example, high-income countries treat, on average, 70 per cent of wastewater, whereas low-income countries only treat 8 per cent (Sato *et al.* 2013). Less than 25 per cent of the 94 respondent countries in The Global Analysis and Assessment of Sanitation and Drinking-Water (GLAAS) 2014 survey had national sanitation plans that were fully implemented, funded and reviewed (UN-WATER *et al.* 2014).

Waterborne pathogens have a devastating effect on human health (Global Goal 3), especially in the developing countries of Sub-Saharan Africa and Southeast Asia (Shannon *et al.* 2008). Children under five years old are particularly vulnerable to water-related disease (Corcoran *et al.* 2010). Diarrhoeal diseases have the highest preventable disease burden from environmental risk (UNEP 2016h). Neglected tropical diseases, such as Chagas disease, are endemic in 149 countries and affect more than a billion of the world's poorest

people. Although not commonly fatal, they are associated with chronic disability, malnutrition, stigma and social exclusion, poor mental health, and decreased educational and employment opportunities (Waite *et al.* 2016). In order to interrupt the transmission routes of such diseases, it is critical that their control is integrated with water sanitation and health (Waite *et al.* 2016). Indeed, the neglect of water sanitation and health undermines the capacity of a country to prevent and respond to disease outbreaks (UN-WATER *et al.* 2014).

Interventions to improve drinking water and sanitation decrease risks of diarrhoea – the use of water filters, high-quality piped water and sewer connections have been found to be most effective in reducing illness (Wolf *et al.* 2014). Fewtrell *et al*. (2005) highlighted that multiple-focus interventions which combine water, sanitation and hygiene measures are no more effective than single-focus interventions. Water sanitation and health interventions do show a small benefit on childhood nutrition and growth, but there is very little quality evidence in this area, so further studies are required (Dangour *et al.* 2013). Pioneered in Bangladesh in 2000, Community-led Total Sanitation (CLTS) is a methodology for mobilising communities to completely eliminate open defecation. It is now present in more than 60 countries and it is estimated that 20 to 30 million people live in communities that can creditably be declared open-defecation free (Bongartz *et al.* 2016). The CLTS methodology enables sustainable improvements to water sanitation and health (Cavill *et al.* 2015).

Reducing pollution

In both developing and industrialised nations, a growing number of contaminants are entering water supplies from human activity. These range from traditional compounds, such as heavy metals and distillates, to emerging micropollutants, such as endocrine disrupters and nitrosoamines (Shannon *et al.* 2008). Pollutants affecting water quality occur as a result of several types of human-environment interactions, including agriculture (Global Goal 2), industry (Global Goal 9 and 12), energy production and extractive processes (Global Goal 7).

The amount of suspected harmful agents is growing rapidly, and many of these compounds are toxic in trace quantities (Shannon *et al.* 2008). The occurrence of emerging or newly identified contaminants in water resources is of concern for the health and safety of the consuming public. For instance, endocrine-disrupting chemicals comprise pharmaceuticals, personal care products, surfactants and various industrial additives. These have become a threat to our water supply network as existing conventional water treatment plants are not designed for such new contaminants (Bolong *et al.* 2009).

Conventional methods of water disinfection, decontamination and desalination can address many pollution problems. However, these methods are often chemically and/or energetically intensive, and focused on large systems, so require considerable capital investment, engineering expertise and infrastructure (Shannon *et al.* 2008). Thus, new and alternative approaches are being considered; for instance, the Centres for Disease Control and Prevention have introduced the use of sunlight irradiation of polymer bottles to kill pathogens (Shannon *et al.* 2008).

Bioremediation can be efficient to treat groundwater contaminated with heavy metals (Kulshreshtha *et al.* 2014) and agrochemicals (Adeoye *et al.* 2013). Immobilisation, soil washing, and phytoremediation are listed among the best available technologies for cleaning up heavy metal-contaminated soils (Wuana *et al.* 2011). Despite this, preventive measures must be the priority because the treatment of groundwater polluted by agrochemicals is often long-term, expensive and not even feasible in some cases (Turall 2012). Simple techniques, such as the construction of riparian buffer strips, can reduce loads to rivers in a cost-effective way that also benefits local ecology (e.g. habitat creation). It should be noted that some remediation techniques for water quality problems caused by rain-fed agriculture (such as reforestation/afforestation and agricultural land management) can decrease water quantity (Scanlon *et al.* 2007).

Water use efficiency across all sectors

Since 1900, the consumption of water for human use has outpaced population growth. Consumption has increased from 600 billion cubic metres in 1900, to 4,500 billion cubic meters in 2010. Under a business as usual scenario, UNEP (2012) predicts that global water demand will outstrip supply by more than 40 per cent by 2030. Additionally, climate change is expected to impact future water supply and demand; indeed, supply and demand increase significantly with increasing greenhouse gas concentrations (Bruckner *et al.* 2014). Many regions of the world are experiencing growing water stress (Haddeland *et al.* 2014). This arises from a growth in demand for water with only a static or diminishing supply. This is compounded by periodic droughts due to climatic factors. While modelling indicates that human impacts on long-term global terrestrial water balance are small, impacts are significant in several large river basins (UNEP-DHI *et al.* 2016).

Currently, agriculture accounts for 70 per cent of global freshwater withdrawals, while the industrial and domestic sectors account for the

remaining 20 per cent and 10 per cent, respectively; these figures vary considerably across countries, however (FAO 2012) (Global Goals 2, 7, 9). Globally, rain-fed agriculture is the predominant production system and current productivity is, on average, little more than half the potential obtainable under optimal management. Since the 1950s, irrigated agriculture has expanded significantly (174 per cent). Surface water based irrigation reduces streamflow and often raises water tables, whereas, groundwater-fed irrigation lowers water tables in many areas, also reducing streamflow (Scanlon *et al.* 2007). Furthermore, climate change is projected to reduce renewable surface water and groundwater resources significantly in most dry subtropical regions and so intensify competition for water (Jiménez Cisneros *et al.* 2014).

The majority of water withdrawn from rivers, lakes and aquifers is returned to the environment. Agricultural and livestock users return the least (30 to 40 per cent), whereas industrial and municipal users return 75 to 98 per cent (Shannon *et al.* 2008). Water reclamation and reuse projects capture water directly from industry or municipal wastewaters. However, return waters contain contaminants and pathogens, and organic matter, which should be removed or transformed to harmless compounds before reuse. The use of reclaimed water in agriculture is an option that is increasingly being investigated and adopted in regions with water scarcity, growing urban populations and growing demand for irrigation. A recent Food and Agriculture Organisation (FAO) survey found more than 3,300 water reclamation facilities existed in around 50 countries, covering about 10 per cent of all irrigated land. The costs of such reuse can be considerable in some regions. Yet, where climatic and geographical features are suitable, the low-cost treatment of wastewater may be an option via the use of stabilisation ponds, constructed wetlands and other mechanisms (Winpenny *et al.* 2010).

Drip irrigation prominently features in water policy debates as a possible solution to water scarcity problems, based on the assertion that it will improve water-use efficiencies. However, a recent review concluded that, despite the overall enthusiasm for drip as a water-saving tool in many policy documents, expectations of increased water efficiencies associated with drip will only be realised in very specific circumstances (van der Kooij *et al.* 2013). Although several studies show that drip irrigation potentially uses less water for a single plot without compromising yield, it has yet to be assessed at the river basin or watershed level (van der Kooij *et al.* 2013).

In developed countries, industrial water use may be stabilising due to increased efficiency and the move of manufacturing to low-income countries. Despite this, a lack of access to water may hinder such moves, especially for water-dependent industries (UN-WATER *et al.* 2014). Future water efficiency within the energy sector could vary due to a number of factors, but efficiency could be increased with advanced cooling systems (IEA 2015). Increasing reliance on nuclear power and fossil fuel energy with carbon capture and storage deployment (Global Goal 7) could significantly increase water consumption (Mielke *et al.* 2010). Biofuel water efficiency will depend on a shift from first generation biofuels (dependent on feedstock crops), to second and third generation biofuels with less water-intensive feedstocks (IEA 2015). Renewable energy technologies, such as wind and solar photovoltaic, use almost no water (Mielke *et al.* 2010).

Integrated water resources management

Integrated water resources management (IWRM) is defined by the Global Water Partnership as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems". In the current definition, IWRM rests upon three principles that act together as the overall framework: (i) social equity; (ii) economic efficiency; and (iii) ecological sustainability (UN-WATER *et al.* 2014). Since 1992, 80 per cent of countries have embarked on reforms to improve the enabling environment for water resources management based on the application of IWRM. Overall, countries have reported a gradual, but positive, trend in financing for water resources development and management, with more diverse sources of finance; yet, there is little progress towards payment for water resources services (UNEP 2012d).

Protecting and conserving water-related ecosystems

Freshwater ecosystems provide a number of provisioning services, including water consumption, non-consumptive water uses, and aquatic organisms for food and medicine. These systems also have a role in supporting nutrient cycling, predator-prey interactions and ecosystem resilience (Global Goal 15). In terms of usable water, water-related ecosystems provide services that maintain water quality, while buffering against floods and water erosion. Recent research suggests a link between freshwater biodiversity and stable, high-yielding fisheries (Brooks *et al.* 2016) (Global Goal 15).

The protection of natural catchments and water bodies is a fundamental part of ensuring the supply of high-quality, regulated water for irrigated

agriculture, hydroelectric power, urban populations, and aquifer recharge. Protected areas are already providing important supplies of freshwater to people, and decreasing the threat to those supplies (Harrison *et al.* 2016).

Currently, inland waters are among the most threatened of all ecosystems. Anthropogenic threats to global freshwater biodiversity fall into five categories: (i) overexploitation; (ii) water pollution; (iii) flow modification; (iv) destruction or degradation of habitat; and (v) invasion by exotic species. Their combined and interacting influences on biodiversity are now worldwide, and exacerbated by global environmental changes, such as nitrogen deposition and climate change (Dudgeon *et al.* 2006). Environmental and anthropogenic water stresses often occur in the same transboundary river basins, resulting in competition for water between sectors and between countries. Risks to transboundary river basins are projected to increase in the next 15 to 30 years, particularly in parts of the Middle East, Central Asia and Southern Africa (UNEP-DHI *et al.* 2016).

Together, forest and mountain ecosystems provide the largest freshwater supply worldwide. Therefore, protecting these ecosystems is key to sustaining the availability and quality of water. Water conservation, soil protection and flood/drought mitigation provided by forests are paramount to human welfare and environmental sustainability. Furthermore, forests can be managed to mitigate the negative effects of climate change on water resources and ecosystems, including supplying water and reducing the risk of floods and droughts (IUFRO 2014) (Global Goal 13).

1.7.4 Knowledge and research gaps

Knowledge and research gaps on environment-human interactions related to water include:

Management and governance

- Guidelines for siting, designing and optimising dams for multiple purposes, while minimising negative ecosystem impacts and sediment trapping (UNEP-DHI/UNEP 2016).
- New standards and practices for management to promote transparency and accountability, increase effectiveness of water sector investments, and reduce corruption (Cooley *et al.* 2013).
- Information for local communities (e.g. education, outreach) to ensure that knowledge/technology transfer efforts are not always top-down processes (UNEP 2012d; Cooley *et al.* 2013)
- Development of new lending standards and compliance strategies in order to ensure that funders abide by environmental and social standards (Cooley *et al.* 2013).
- Research to integrate capacity building and resilience in development policy (Gopalakrishnan 2013).
- Large watershed studies to understand interactions between forests and water (IUFRO 2014); especially in tropical Africa (Dudgeon *et al.* 2006).
- Development of an accurate database on water diseases (Gopalakrishnan 2013).
- Research on climate-induced vulnerability (Gopalakrishnan 2013).

Water treatment

- Information on wastewater generation, treatment and use. Of 181 countries, only 55 countries have available data on all three aspects of wastewater, while 57 have no data; where data is available, it is often old (Sato *et al.* 2013).
- Development of advanced wastewater treatment technologies, including those that are: able to detect and eliminate new and unregulated micropollutants (endocrine-disrupting chemicals) (Shannon *et al.* 2008; Bolong *et al.* 2009); more compact and efficient, e.g. membrane technologies (Bolong *et al.* 2009) and alternatives to chlorine (free and combined); capable of UV disinfection for the control of waterborne viruses; and are able to incorporate active nanocatalysts in a membrane barrier (Shannon *et al.* 2008).
- Decoupling of cooling systems from freshwater resources via saltwater or dry cooling, developing better wastewater use and integrating renewables in desalination/irrigation (WEC 2016a).

Freshwater biodiversity

- Data on freshwater biodiversity at a global scale (Harrison *et al.* 2016), specifically, in-lake and near-lake scientific data, in order to make global assessments easier (ILEC *et al.* 2016).

Water demand

- Improved information systems on groundwater resources and flows for all countries using or planning to use groundwater for irrigation, and how to better enforce policies on sustainable use (OECD 2015a).
- Defining and designing infrastructural and technological changes to reduce water use in energy production. Methodologies that integrate water availability into design must balance concerns regarding energy security, affordability and sustainability (WEC 2016a).

1.7.5 Overview of networks and funding

There are range of organisations and networks currently involved in water-resource management:

global water partnerships (e.g. Water Footprint Network); non-governmental organisations (e.g. WaterAid); and intergovernmental initiatives (e.g. UNICEF's Water, Sanitation and Hygiene team and UN's GLAAS). Aid commitments for water and sanitation to all sectors from donors reporting to the Organisation for Economic Co-operation and Development – Common Reporting Standards (OECD-CRS) increased from USD 8 billion in 2010, to USD 11 billion in 2012 – a 30 per cent increase (UN-WATER *et al.* 2014). Data suggests that national government budgets and expenditures for water, sanitation and hygiene are also increasing but there remains a huge financing gap between budget and plans, with 80% of countries indicating insufficient financing for the sector (UN-WATER *et al.* 2014). Reported government-coordinated expenditure (from taxes and transfers) on sanitation and drinking water ranged from less than 0.01 per cent to 1.78 per cent of GDP. In the GLAAS 2014 country survey, of the 12 major external support agencies, funding included USD 80 million from the Bill and Melinda Gates Foundation, SEK 410 million from Sweden, and CHF 150 million from Switzerland (UN-WATER *et al.* 2014).

1.8 GLOBAL GOAL 7: ENSURE ACCESS TO AFFORDABLE, RELIABLE, SUSTAINABLE AND MODERN ENERGY FOR ALL

1.8.1 Summary of Global Goal

The overall aim of Global Goal 7 is to ensure access to affordable, reliable, sustainable, and modern energy for all. Specifically, it strives to ensure universal access to affordable, reliable and modern energy services; substantially increase the share of renewable energy in the global energy mix; and double the global rate of improvement in energy efficiency.

There are several multilateral environmental agreements that are relevant to Global Goal 7. The United Nations Framework Convention on Climate Change (UNFCCC) is acknowledged as the primary intergovernmental forum for negotiating the global response to climate change (Global Goal 13), which will require a change in global energy use. The Ramsar Convention promotes the awareness of the potential impacts of the energy sector on wetlands. In addition, the Convention on the Conservation of Migratory Species of Wild Animals aims to mitigate the impacts of climate change on migratory bird species, which includes ensuring adequate environmental safeguards for renewable energy projects.

1.8.2 Overview of main environment-human interactions

All power generation derives from, and impacts, the environment. In particular, fossil fuels – which dominate the current energy landscape – have repercussions for air and water quality, public health, wildlife and climate change. The world demand for energy is predicted to double by 2050. In order to meet these demands, and prevent the damaging effects of energy produced with fossil fuels, significant, worldwide investments are needed in renewable energy (UNEP 2015c). The proportion of renewable energy derived from hydropower, solid and liquid biofuels, wind power, solar power, biogas, and geothermal and marine sources and waste grew by an estimated 5 per cent in 2015; it now accounts for around 23 per cent of total electricity generation globally (IEA 2016b). The Millennium Ecosystem Assessment (MA 2005) discusses a number of renewable energy sources and their use as fuel, including fuelwood, charcoal and biomass energy, as well as their drivers of change in the ecosystem services context.

Energy is crucial for achieving almost all of the Global Goals. It plays a vital role in the eradication of poverty (Global Goal 1) and advancements in health (Global Goal 3), education (Global Goal 4), water supply (Global Goal 6) and industrialisation (Global Goal 9). It is also pivotal in combating climate change (Global Goal 13). Access to energy for heating, transportation and production is essential to maintaining human health (Global Goal 3). Conversely, the energy sector is one of the main causes of the global air pollution health crisis. Each year, 7 million deaths are attributed to poor air quality, with 3.5 million deaths across the developing world (largely Asia and Sub-Saharan Africa) being attributed to emissions from the incomplete burning of biomass (IEA 2016a).

1.8.3 Synthesis of developments in research, innovations and policies

Non-renewable energy sources

Oil, gas and coal

Under a business as usual scenario, fossil fuels are set to continue to provide around 60 per cent of additional energy and 80 per cent of total energy supplies by 2035 (BP 2016). In 2015, oil was the world's leading fuel, accounting for 32.9 per cent of global energy consumption (Johansson *et al.* 2012; BP 2015). Fossil fuel extraction can result in ecosystem disturbance and degradation; direct impacts include habitat destruction and fragmentation, visual and noise disturbance and pollution, while indirect impacts include soil erosion, water pollution and oil spills (Butt *et al.* 2013). Oil spills pose particularly serious environmental challenges for both terrestrial and

marine ecosystems (Global Goals 14, 15) (Macaulay *et al.* 2014). During the past 60 years, more than 5.5 million tonnes of oil have been released along mangrove-lined coastal waters, killing more than 126,000 hectares of mangrove vegetation (Duke 2016). Deep-sea ecosystems (such as cold-water corals) generally have low resilience to, and struggle to recover from, disturbances associated with deep-water drilling, so a precautionary approach to offshore oil and gas extraction is required (Cordes *et al.* 2016).

Power generation from coal and oil are the dominant source of anthropogenic emissions of sulphur dioxide, followed by industrial energy combustion (Amann *et al.* 2013). It is thought that sulphur dioxide emissions peaked around 2006 (Klimont *et al.* 2013), although there is strong spatial variability. North America and Europe have reduced their sulphur dioxide pollution by two-thirds, increasing energy efficiencies and using end-of-pipe desulphurisation technologies. China remains a key emitter (one third of global sulphur dioxide), but an ambitious programme of flue gas desulphurisation has resulted in significant declines (Amann *et al.* 2013).

Nuclear

In 2012, Nuclear power plants provided approximately 11 per cent of the world's electricity production (IEA 2015). Nuclear output grew by 1.3 per cent in 2015, with China accounting for a majority of the increase (BP 2015). In Organisation for Economic Co-operation and Development (OECD) countries, both radioactive and hazardous wastes, which could potentially harm humans and the environment, are thought to be strongly regulated and safely managed. The small quantities of radioactive waste, mainly arising from a very limited number of producers, has meant that temporary storage has been a largely safe and economically viable option to date. However, safety failings at the Sellafield plant in the UK, for example, highlight that this is not always the case. Furthermore, as of 2010, no final disposal facilities were available in any country (OECD 2010).

Renewable energy sources

A move to sustainable energy requires a fundamental shift away from fossil fuels to clean, decarbonised energy production. Such a transition is feasible with known technologies (Johansson *et al.* 2012) and is slowly underway across the world, driven by international policy and global governance agreements, increasing electrification in India, and a reduced energy intensity growth model in China (IEA 2015; IEA *et al.* 2015). The environmental impacts associated with renewable and low greenhouse gas energy systems result from changes in land cover, land use (Global Goal 15) and water use (Global Goal 6), as well as the physical modification of the environment (UNEP 2015c). Additionally, an important area for consideration is the environmental impacts of extracting materials for, and producing, renewable energy technologies. The scale and deployment of low-carbon facilities varies widely, thus their impact on local biodiversity (Global Goals 14, 15) is different in each case (UNEP 2015c).

Hydropower

Hydropower provides around 6 per cent of the total global energy supply, and is growing by 3 per cent every year. Globally, the number of dam constructions has increased dramatically over the past six decades and is forecast to continue to rise, particularly in less industrialised regions (Grill *et al.* 2015). Despite the renewable nature of hydropower, this technology can result in severely adverse social and ecological effects, such as the relocation of people, transboundary conflicts, fragmentation of free-flowing rivers, and habitat changes, further threatening freshwater biodiversity (Zarfl *et al.* 2014). On a global scale, 48 per cent of river volume is moderately to severely impacted by either flow regulation, fragmentation, or both. This percentage is predicted to nearly double (to 93 per cent) by 2030, largely due to major dam construction in the Amazon Basin (Grill *et al.* 2015). Increased commitment is needed by organisations, such as the International Commission on Large Dams, to improve guidelines and reflect contemporary principles of transboundary water management (UNEP-DHI *et al.* 2016).

Marine, solar and wind

There is little data in relation to the impacts that marine renewable energy developments (MREDs) may have on the marine environment (Global Goal 14) (James 2013). Negative effects are considered to include construction, noise and collisions (Attrill *et al.* 2013), while positive effects include the provision of new habitats for wildlife (James 2013; UNEP 2015c). However, one 10-year monitoring study has shown no major impacts, and little evidence of marine mammals colliding with turbines (Attrill *et al.* 2013). Furthermore, due to the production of photovoltaic cells, solar energy raises more concerns over ecotoxicity in both the terrestrial and marine realms than hydropower and wind power (UNEP 2015c).

Fuelwood and charcoal

More than half of all wood harvested worldwide is used as fuel, supplying approximately 9 per cent of global primary energy (Bailis *et al.* 2015). Due to urbanisation and development (Global Goals 8, 11), fuelwood use is decreasing in many parts of the world. However, in Africa, the consumption of fuelwood is increasing, resulting in additional

pressure on forest resources (FAO 2008). Across the tropics, about 1.4 billion cubic metres of firewood are used each year, and around 40 million tonnes of charcoal are produced (May-Tobin 2011). Currently, 27 to 34 per cent of fuelwood is considered to be unsustainably harvested, but there are large geographic variations (Bailis *et al.* 2015). The use of firewood is expected to remain relatively stable over the next 20 years, while charcoal use is expected to increase considerably (May-Tobin 2011). The emissions from the burning of fuelwood contributes around 2 per cent of global greenhouse gas emissions (Global Goal 13) (Bailis *et al.* 2015), and is also considered a major health risk (Global Goal 3). In Virunga Park, Democratic Republic of the Congo (DRC), the illegal charcoal trade is estimated to make rebel organisations around USD 8 million per year and is a major threat biodiversity (May-Tobin 2011).

Bioenergy sources

The period between 2000 and 2010 saw a 20 per cent, year-on-year increase in biofuels production (Timilsina 2014). Despite this, biofuels only accounted for around 3 per cent of global road transport fuel in 2012 (Bruckner *et al.* 2014). In 2012, 98 per cent of all biofuel production was in the form of ethanol from sugars and biodiesel from oil seeds (i.e. first generation biofuels) (Atabani *et al.* 2012). The rapid growth of biofuels has raised concerns over food security (Global Goal 2), biodiversity (Global Goal 15) and indirect land-use change (Searchinger *et al.* 2008).

The use of biofuels reduces greenhouse gas emissions relative to fossil fuels (Timilsina 2014), but the impacts of land-use change need to be considered when assessing their environmental, and biodiversity, interactions. However, calculating biodiversity debt due to land-use change is not possible; biodiversity is not measurable along a single metric and, therefore, cannot be aggregated (Bertzky *et al.* 2011). Moreover, the water requirement for the major biofuel feedstocks is substantial, resulting in potential strains on water supply (Global Goal 6) (Timilsina 2014).

Current recommendations to avoid negative environmental outcomes from biofuel production include: successful implementation of enforceable national and international standards and reliable compliance mechanisms; traditional land rights and usage recognition; small-scale production encouragement; and the development of new biofuel technologies (Mukherjee *et al.* 2014). Second generation fuels (biomass and waste product conversion), and third generation fuels (such as algae) are not yet widely deployed (Campbell *et al.* 2009). Some biofuel feedstocks identified for second generation fuels are classified as invasive species. Introduction of these species would require careful management to avoid unintended consequences for biodiversity (Timilsina 2014). In the case of algal-based fuels, the limited available evidence indicates these have high production costs relative to other energy sources, high energy and water requirements, and potentially positive and negative environmental impacts (Slade *et al.* 2013).

Access to energy

The proportion of the global population with access to electricity has increased steadily, from 79 per cent in 2000, to 85 per cent in 2012. Yet 1.1 billion people are still without electricity, and inequalities exist in the access of services (Global Goals 5, 10). Current investment flows of USD 400 billion a year would need to triple to achieve universal access (IEA *et al.* 2015). Climate change has also been linked to potential changes in access to energy (Global Goal 13). Power lines and pipelines (referred to as Industrial Linear Corridors [ILCs]) provide access to energy, and can have wide-ranging environmental effects (Latham *et al.* 2015). Effective mitigation of such effects involves strategies to reduce the number and duration of ILCs in the landscape and the impacts caused by associated structural elements (Latham *et al.* 2015).

Improving the environmental sustainability of energy production

Impact of energy production

Energy production is the largest anthropogenic source of global greenhouse gases, and emissions have grown rapidly since 2000. In 2010, the energy sector was responsible for around 35 per cent of anthropogenic emissions (Bruckner *et al.* 2014).

Energy used in transportation is responsible for the majority of anthropogenic nitrogen oxide emissions. However, the relative contribution of vehicle emissions has decreased in recent years, while emissions from power generation continues to grow; by 2010, power generation constituted around 40 per cent of the global total. Emissions from North America and Europe have declined sharply, while emissions from Asian countries have almost doubled in the past two decades. The increase in emissions of nitrogen oxide seen in developing countries has been mainly due to the growth of the power sector, which currently lacks emission-control legislation (Amann *et al.* 2013).

The energy sector is the second largest user of freshwater after the agricultural sector (Global Goal 6). Indeed, 98 per cent of current power production requires water (WEC 2016b). The overall water footprint of this sector could be lowered by using more renewables and natural gas to produce power and heat as they use

comparatively less water. Reductions in usable water capacity could impact two-thirds of hydropower plants and more than 80 per cent of thermal electric power plants globally (WEC 2016b).

Waste-to-energy technologies
Waste-to-energy technologies can be applied to several types of waste, from semi-solid (such as thickened sludge from effluent treatment plants), to liquid (such as domestic sewage) and gaseous (such as refinery gases) waste. The most common application is processing Municipal Solid Waste (MSW) via incineration in combined heat and power plants. The main drivers of incineration are increasing waste generation, high energy costs, growing concerns over environmental issues, and restricted land-filling capacities; however, the complexity of MSW facilities and their emissions represent issues for this technology (WEC 2013).

Energy efficiency
Efficiency improvement is proving to be the most cost-effective, near-term option for creating multiple benefits, including the reduction of adverse environmental and health impacts (Global Goal 3), poverty alleviation (Global Goal 1), employment creation (Global Goal 8), and enhanced energy security and flexibility. Improvements in energy efficiency can be achieved relatively quickly by retrofitting old buildings and designing new ones (Global Goal 11), using electrically powered transportation, and better integrating spatial planning and travel (Johansson *et al.* 2012).

Grid-connected energy storage systems provide grid stabilisation, frequency regulation, and wind and/or solar energy smoothing (Poullikkas 2013); in future, this will become more important on a global scale in response to an increasing share of overall energy produced by intermittent renewable resources. Currently, pumped hydro storage is the only widely used storage technology, but other storage systems (such as compressed air, thermal, flywheel, superconducting magnetic, and redox flow batteries) may be deployed with varying levels of scalability, flexibility, environmental impact and potential safety issues (Alotto *et al.* 2014; Bruckner *et al.* 2014). Smart grids allow users to potentially better manage their electrical demand or output, but future success is likely to be mediated through government organisations (GSGF 2012).

Carbon Capture and Storage
Carbon Capture and Storage (CCS) has applications across both the power and non-power sectors, including in processes that may have no alternative for deep-emissions reductions (such as cement and steel). Nevertheless, no new investment decisions or advanced planning for projects was undertaken in 2015, and CCS is struggling to emerge as a sound low-carbon choice for governments and investors (D'Aprile 2016). Industry and governments will need to make significant investments in projects and technology development to get CCS on track to meet climate change targets (Global Goal 13) (IEA 2016b). Expanding CCS will require reducing its costs, supporting up-scaling, assuring carbon storage integrity and environmental compatibility, and securing approval of storage sites (Johansson *et al.* 2012).

1.8.4 Knowledge and research gaps

Further research and investigation is needed in the following areas:

Energy-infrastructure-investment nexus
- Modelling tools that adequately reflect risks posed by the decisions regarding the energy-infrastructure-investment nexus (WEC 2016b).
- The shift to a less fossil fuel-dependent food sector (FAO 2011a).

Non-renewable energy sources
- The impact of deep-water drilling to enable the development of a common, global standard for deep-water environmental protection (Cordes *et al.* 2016).
- The application of water footprinting methodologies for mining and extractive industries, including data on: mine-site water use; mining supply chains; post-closure impacts; cumulative impacts; and extreme events (Northey *et al.* 2016).
- Air pollutant emissions from some regions/sectors are derived from incomplete, bottom-up data (i.e. lab-based research) (Amann *et al.* 2013).
- Policies and programmes to support bioenergy and fuelwood use (FAO 2008).

Nuclear power
- The speciation and reactions of multivalent radionuclides and their transport behaviour in the environment.
- Managing and remediating contamination at legacy nuclear facilities (Hu *et al.* 2010).

Renewable energy sources
- Improved predictions of how future dam construction will affect biodiversity, ecosystem functioning and fluvial geomorphology to aid sustainable dam development (Grill *et al.* 2015).
- Energy efficiency, renewable energy and CCS (Johansson *et al.* 2012).
- The combined effects of current and new energy facilities on particular species, such as birds of prey (UNEP 2015c).

- The consequences of species displacement due to renewable and marine energy sources (Attrill *et al.* 2013).
- The impacts on biodiversity from indirect land-use change for biofuel production (Bertzky *et al.* 2011).
- The rapid development of biofuels and the link between human activities and the global nitrogen cycle (Galloway *et al.* 2008).
- The potential use of marginal and degraded land to produce biomass for energy generation (FAO 2008).

1.8.5 Overview of networks and funding

Numerous intergovernmental agencies, non-governmental organisations (NGOs) and project networks focus on energy issues. In terms of knowledge development, synthesis and coordinating action, core agencies include the International Energy Agency (IEA), the International Atomic Energy Agency (IAEA) and the International Renewable Energy Agency (IRENA). The IEA focuses on four main work areas: energy security; economic development; environmental awareness; and global engagement. The IAEA focuses on promoting the peaceful use of nuclear energy, and IRENA supports the transition to sustainable energy futures through international cooperation and the provision of a centre for excellence on renewable energy policy, technology, resources and finance. The International Commission on Large Dams (ICOLD) is a NGO that has National Committees from more than 90 countries and approximately 10,000 individual members. The Integrated Solutions for Water, Energy and Land project was launched in 2015 as a collaboration between the International Institute for Applied Systems Analysis (IIASA), the Global Environment Facility (GEF) and the United Nations Industrial Development Organisation (UNIDO).

In terms of funding for the major energy agencies, funding information and accounts for the IEA are not readily available, while the IAEA's 2016 budget was around USD 400 million, and IRENA has a core budget of USD 43 million over its 2016 to 2017 work programme.

1.9 GLOBAL GOAL 8: PROMOTE SUSTAINED, INCLUSIVE AND SUSTAINABLE ECONOMIC GROWTH, FULL AND PRODUCTIVE EMPLOYMENT AND DECENT WORK FOR ALL

1.9.1 Summary of Global Goal

Sustained and inclusive economic growth is necessary for achieving sustainable development (UNECOSOC 2016b). Global Goal 8 calls for per capita economic growth in accordance with national circumstances, increases in economic productivity, decent job creation, entrepreneur-ship, full and productive employment, sustainable tourism, labour rights, safe and secure working environments for all workers and increased capacity of domestic financial institutions. It call calls for decreases in youth unemployment and eradication of forced and child labour. Additionally, Global Goal 8 has the aim of global resource efficiency in consumption and production, and the decoupling of economic growth from environmental degradation. Sustained, inclusive, equitable and sustainable economic growth represents a fundamental shift from today's unsustainable economic model. To make this shift, pervasive and deep-rooted inequalities will need to be addressed, including equitable access to natural resources (Bowen *et al.* 2014; UNEP 2016b). This is of particular concern in developing countries that are unable to diversify from primary production and where the rural poor bear the brunt of resource depletion (Global Goal 1) (TEEB 2011; Barbier 2016).

Decoupling economic growth from environmental degradation and increasing resource efficiency are closely linked to the 10- year framework of programmes (10YFP) on sustainable consumption and production patterns adopted by countries at the Rio+20 Conference (Global Goal 12) (UNCSD 2012).

1.9.2 Overview of main environment-human interactions

A central component of Global Goal 8 is the decoupling of economic growth from environmental degradation. Current economic growth patterns are neither equitable nor environmentally sustainable (World Bank 2012). The Millennium Ecosystem Assessment (2005) estimated that approximately 60 per cent of the ecosystem services that support life on Earth – such as soil, water and climate regulation – are changing, or being degraded or used unsustainably (UNEP 2016b). Yet, natural resources and ecosystem services are essential for sustained economic growth and development, and are a prerequisite for poverty eradication (UNEP 2014; UNEP 2016b; UNEP 2016i) (Global Goal 1). Additionally, there are large adverse environmental impacts from economic activity that both directly and indirectly affect human welfare as measured through lower output (Bowen *et al.* 2014). For example, outdoor air pollution could cause 6 to 9 million premature deaths a year by 2060 and cost 1 per cent of global Gross Domestic Product (GDP) as a result of sick days

(OECD 2016a) (Global Goal 3). Therefore, future prosperity for all will require that economic growth no longer degrades the environment, and maintains the Earth system within defined planetary boundaries (Steffen *et al.* 2015).

The aim is for a global 'green economy' – one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. This will mean changes to production systems, employment patterns and technologies in every country, as well as accompanying behaviours that influence consumption (Global Goal 12) and societal cohesion. Understanding that a healthy, well-functioning environment is crucial for humankind to prosper is key to making this transition; a transition which presents societies with major challenges (Bowen *et al.* 2014).

1.9.3 Synthesis of developments in research, innovations and policies

Current environmental impacts of growth

The high material throughput model of current economic growth is unsustainable. Non-renewable resource stocks, such as phosphates, are rapidly diminishing (Steffen *et al.* 2015), while renewable resources, such as global fish stocks, are being exploited at a rate beyond their capacity for renewal (Global Goal 2, 12, 14 and 15) (FAO 2016b). Total material extraction has grown by more than 90 per cent over the past 30 years, reaching almost 70 billion tonnes today (von Weizsäcker *et al.* 2014). Over the same period, trade volumes in physical terms have increased by 150 per cent; and, in 2009, 9.3 billion tonnes of raw materials and products were traded around the globe (Global Goal 12) (Giljum *et al.* 2014).

Green economy, green growth

Shifting to a green growth model where well-being is at the centre of development, while ensuring that natural assets continue to provide the resources and environmental services to support sustainable development, will support the development of a green economy. A green economy should maintain, enhance and, where necessary, rebuild natural capital (the stocks of Earth's natural assets and resources, such as soil, water, air and biodiversity) as a critical economic asset and as a source of public benefits, especially for poor people whose livelihoods and security depend on nature (Global Goals 1, 6, 7, 14 and 15) (UNEP 2011b). Decoupling of material use and throughput from economic growth is essential to green growth, and there are two types of decoupling. Relative decoupling involves a reduction in material-use intensity, while absolute decoupling involves a reduction in the rate of resource use irrespective of the growth rate of economies (UNEP 2011b).

There is evidence of relative decoupling of domestic water use (per GDP growth) in most countries since the 1980s. However, the efficiency gains in water consumption have been more than offset by an absolute increase in overall water use (Global Goal 6) (UNEP 2015d). While there is evidence of modest, absolute decoupling of economic growth within some countries (Knight *et al.* 2014; von Weizsäcker *et al.* 2014; Handrich *et al.* 2015; UNEP 2015b), these analyses do not account for the impacts of burden shifting and the embedded material throughput involved in globally diffuse production chains. When taking into account indirect and consumption-based emissions, there is currently no evidence of absolute decoupling of economic growth and resource use on a global scale (Giljum *et al.* 2014; Knight *et al.* 2014; von Weizsäcker *et al.* 2014; Mir *et al.* 2016).

Magnitude of change required to transition to a green economy

Rapid action in both developed and developing countries is required in order to transition the world to a green economy which is low carbon, resource efficient and socially inclusive (UNEP 2011b; World Bank 2012; Barbier *et al.* 2013). Piecemeal, incremental progress on a business as usual basis in the coming decades will not be enough to avoid the significant costs and consequences of inaction (OECD 2012a). The transition will require large, system-wide and structural changes (Bowen *et al.* 2014; Bowen *et al.* 2016). This will involve the removal of obstacles to decoupling that arise from political, technological, behavioural, organisational and institutional bias and lock-in (von Weizsäcker *et al.* 2014).

The role of the state in implementing long-term green economy regulatory frameworks is central and will require going beyond correcting market failures (Bowen *et al.* 2014; Pahle *et al.* 2016). The state must provide overall strategic direction (Bowen *et al.* 2014), and play a key role in innovation, changing consumption patterns, and production (Global Goals 9 and 12) (Grubb 2014; Mazzucato *et al.* 2014; Mazzucato 2015; Jacobs *et al.* 2016). Low-carbon energy technologies (Global Goal 7) are also essential for achieving sustainable economic development (Barbier *et al.* 2013) that supports climate change mitigation (Global Goal 13). Performance continues to be constrained by the protracted effects of the global financial crisis, deeply embedded market failures, underlying weaknesses in policies and institutions, and the inertia and technological lock-in of a longstanding high-carbon economic model (Global Commission on the Economy and Climate 2015).

Transitioning to a green economy

Developing new indicators of sustainable economic growth

What we measure affects what we do (Stiglitz *et al.* 2009), and there is a growing global consensus that GDP does not provide a good overall measure of economic, environmental or societal well-being (ICSU 2015); (Jackson 2009; UNEP 2011b; UN 2014); (Stiglitz *et al.* 2009; Costanza *et al.* 2014). Greater emphasis on new indicators and multivariate measures of current well-being, alongside measures of sustainability (Stiglitz *et al.* 2009), is required for green growth; whereas, there should be less emphasis on increased material throughputs (Jackson 2009; Bowen *et al.* 2014; UNEP 2016b). Recommendations for such measures include: indicators of income and wealth, such as the Inclusive Wealth Index (UNU-IHDP *et al.* 2014); and the overall 'greenness' of the economy (for instance, carbon productivity measured as Goss National Income per capita/carbon dioxide per capita) (ICSU 2015). United Nations Environment Programme recommend using the adjusted net national savings methods of the World Bank and measuring changes in natural capital through the development of a System of Environmental and Economic Accounting (SEEA) (UNEP 2011b).

Natural capital represents a way of framing nature as a stock of assets in order to assess human benefits associated with ecosystem services, and make these visible to policymakers (Kumar 2010; Brown *et al.* 2016). It includes land, minerals and fossil fuels, solar energy, water, living organisms, and the services provided by the interactions of all these elements in ecological systems (UNEP 2012a). A reduction in stocks of natural capital, and in the availability of ecosystem services, has global impacts and disproportionately harms the well-being of the poor, reducing the resilience of communities dependent on local environmental resources (UNEP 2014).

The UN's System of Environmental Economic Accounting-Experimental Ecosystem Accounting (SEEA-EEA) is a multipurpose statistical framework that aims to quantify the relationships between the environment and people. It ultimately aims to allow the integration of information on ecosystems, and the services they provide, with information on economic and other human activity (UN 2012).

The development of environmental and ecosystem valuation and accounting techniques have progressed apace. In 2011, total global ecosystem services were valued at USD 125 to 145 trillion; during the period 1997 to 2011, there was an estimated loss of USD 4.3 to 20.2 trillion per year in ecosystem services (Costanza *et al.* 2014). WWF has recently estimated Gross Marine Product (GMP – a measurement of marine ecosystems) at a minimum of USD 2.5 trillion (Global Goal 14) (Hoegh-Guldberg 2015). However, environmental and ecosystem valuation and accounting techniques are still in the early stages of implementation (Guerry *et al.* 2015); as yet, there is little evidence of successful application and use (Haase *et al.* 2014; Laurans *et al.* 2014). Laurans et al. (2013) found that the vast majority of ecosystem valuations were produced under a 'supply-side' logic, and it is uncertain whether the accounting tools developed match real decision-making needs (Laurans *et al.* 2013). Meeting these needs requires the development of a solid evidence base linking decisions to impacts on natural capital and ecosystems services; development of knowledge, tools and practices to integrate these; and institutional reform in order to align short- and long-term societal goals (Guerry *et al.* 2015).

Assessments of natural capital facilitate the development of a variety of biodiversity finance mechanisms, including initiatives like Payments for Ecosystem Services (PES). These have evolved in recent years, with additional attention being paid to equitable benefits and addressing the needs of the poor (UNEP 2016b). However, the ability to participate in PES schemes is influenced by various socioeconomic characteristics, incentive structures, and the inclusion of poverty-reduction considerations within PES programme design (Adhikari *et al.* 2013).

Finance

Reforms within the financial system are much needed in order to help correct for its short-term, unsustainable orientation. These reforms should be focused on delivering a financial system oriented towards an inclusive, prosperous and environmentally sound future; and achieved through the financing of sustainable development at the same time as complementing both real economy actions and public-finance measures. Momentum towards this objective can be seen within the financial system, with notable leadership from developing, as well as some developed, nations (UNEP 2016c).

Policy, market and broader international drivers underpin this momentum, but they remain inadequate to deliver the transformation needed to finance a transition to a sustainable green economy. Natural capital continues to decline precipitously, social inequality and unrest is growing, sustainable financial flows and stocks remain marginal, the financial system remains disconnected from the long-term needs of the real economy, and financial stability is increasingly threatened by the effects of today's unsustainable economic growth. Aligning the financial system with sustainable economic growth requires:

sustainability to be anchored in national strategies for financial reform; technological innovation to be channeled to finance sustainable development; public finance to be properly leveraged; systemic awareness and capacity building to be undertaken; and sustainability to be embedded within common methods, tools and standards across the financial system (UNEP 2016c).

Removal of perverse subsidies.
Direct subsidies within the energy, agriculture and fisheries sectors have been estimated at more than USD 1 trillion per year (ICTSD 2012). Incentives can have perverse distributive consequences and environmental effects, including land-use changes (Global Goal 15), overexploitation of fish stocks (Global Goal 14), and continued unsustainable energy production (Global Goal 7). There is widespread consensus that the removal of fossil fuel subsidies is essential to a transition to a green economy (UNEP 2015b). Fossil fuel subsidies can take a variety of forms, including direct financial transfers, trade instruments, regulations, tax breaks, credit, risk transfers, and below-full cost access to government goods and services. The reported scale of fossil fuel subsidies varies according to the methodology used, type of subsidy measured and country coverage. Estimates range from USD 544 billion globally in 2012, to USD 2 trillion, including post-tax subsides (UNEP 2015b). Subsidies in OECD countries alone amounted to USD 55 to 90 billion every year between 2005 to 2011 (OECD 2008a). Shifting investment away from new coal-fired power and fossil fuel exploration, and scaling clean energy financing to at least USD 1 trillion per year could reduce annual greenhouse gas emissions in 2030 (Global Goals 7 and 13) (Global Commission on the Economy and Climate 2015).

Green jobs and sustainable tourism
Currently, 2.6 billion people worldwide draw their livelihoods, either partially or fully, from agriculture: 1.6 billion from forests, 250 million from fisheries and 200 million from pastoralism (UNEP 2016f). Greening these sectors will be key to the provision of sustainable livelihoods (Global Goal 1).

Nature-based tourism is defined as tourism that relies on, or travel to, a natural place. Ecotourism is often reviewed as a component of nature-based tourism and represents a set of principles focusing on responsible travel, conservation and local livelihoods. Globally, nature-based tourism is increasing; thus, it is potentially important in providing funding for biodiversity conservation and shaping societies' attitudes to nature (Balmford *et al.* 2009). It is difficult to empirically assess the economic and environmental outcomes of nature-based tourism currently as there is a lack of consistent measurement (Ardoin *et al.* 2015). However, it is estimated that nature-based tourist visits generate around USD 600 billion per year in in-country expenditure (Balmford *et al.* 2015). Innovations have been made in certification for the industry and the further development of standards based on good practice (via the International Ecotourism Society, for example), and concepts around pro-poor tourism have continued to grow (OECD 2008a).

1.9.4 Knowledge and research gaps

Further research and investigation is needed in the following areas:

Green economies, green growth and resource decoupling

- Definitions, and scientific assessment, of concepts of green economy, green growth and the blue economy (marine ecosystem services) and the economic assumptions behind them (Pahle *et al.* 2016).
- Methodologies to analyse, better understand and integrate multiple-objective policies.
- Measurement of resource efficiency and decoupling, through conceptual work to clarify meaning of indicators for resource productivity, allocation of upstream flows to international traded production and identify the best fit between economic variables and material indicators (Giljum *et al.* 2014).
- Material-flow based indicators, especially consumption-based indicators that consider indirect material flows associated with internationally traded products (Giljum *et al.* 2014).
- New measures for understanding progress towards sustainable development and inclusive prosperity, including indicators which look beyond the traditional economic and development gauges (such as GDP and HDI) (Jackson 2009; Stiglitz *et al.* 2009; UN 2012; Costanza *et al.* 2014; ICSU 2015; UNEP 2016b).

Transitioning to a green economy

- Analysis of the impact of renewable energy deployment on short term socioeconomic benefits since evidence from current case studies is mixed (Pahle *et al.* 2016).
- In depth analysis of decision-making processes to which environmental-economic accounting seeks to input, in order to understand potential uses and contexts for ecosystem services valuation (Laurans *et al.* 2014; Guerry *et al.* 2015; Brown *et al.* 2016).
- The outcomes of nature-based tourism using consistent, measurable variables (Ardoin *et al.* 2015).

1.9.5 Overview of networks and funding

Organisations and partnerships that focus on supporting transitions to a green economy,

including poverty reduction, job creation and environmental sustainability, include the Global Green Growth Institute (GGGI); the UN Partnership for Action on A Green Economy (UN-PAGE); and the Green Economy Coalition (GEC). Knowledge platforms include the Green Growth Knowledge Platform (GGKP), Future Earth's Finance and Economics Knowledge-Action network, the Climate and Development Knowledge Network (CDKN), and the Inclusive Wealth Project. Coalitions focused on natural capital include the Natural Capital Coalition, a multi-stakeholder collaboration of organizations from research, science, academia, business, advisory, membership, accountancy, reporting, standard setting, finance, investment, policy, government, conservation and civil society. A number of organisations also support green jobs through ecotourism, such as the International Ecotourism Society, UN World Tourism Organisation (UNWTO).

In terms of major funding commitments, CDKN received funding contributions of around GBP 88 million in 2015 and the GGGI had a total operating income of USD 49 million in 2015. UN-PAGE funding contributions and commitments currently stand at around USD 26 million, while in 2015 GEC stood at USD 6 million and the Future Earth at USD 4.6 million.

1.10 GLOBAL GOAL 9: BUILD RESILIENT INFRASTRUCTURE, PROMOTE INCLUSIVE AND SUSTAINABLE INDUSTRIALISATION AND FOSTER INNOVATION

1.10.1 Summary of Global Goal

Global Goal 9 encompasses three important aspects of sustainable development: infrastructure, industrialization and innovation. Infrastructure provides the basic physical systems and structures essential to the operation of a society or enterprise. However, there remain significant disparities in access to infrastructure worldwide, including water and sanitation infrastructure (Global Goal 6), energy infrastructure (Global Goal 7) and transport infrastructure. For example, approximately one third of the world's population is not served by all-weather roads (UN 2016a). Industrialization drives economic growth (Global Goal 8), creates job opportunities, and reduces income poverty (Global Goal 1). Innovation advances the capabilities of industrial sectors and prompts the development of new skills (UN 2016a).

1.10.2 Overview of main environment-human interactions

Infrastructure plays a crucial role in the drive for achieving development and economic growth (Global Goal 8) (World Bank *et al.* 2007). In order for developing countries to sustain rapid growth rates, they may have to invest more than USD 700 billion a year in infrastructure in the coming decade (World Bank *et al.* 2007). This includes infrastructure for managing environmental resources, such as supplying water and energy (Global Goals 6 and 7), and green infrastructure – an interconnected network of natural and semi-natural elements capable of providing multiple functions and ecosystem services. However, the future development of all infrastructure (including transport and information and communications technology [ICT]) may also have large environmental impacts, such as the release of greenhouse gases, and will need to be resilient to environmental shocks and stressors. The Millennium Ecosystem Assessment (2005) noted the impacts of infrastructure (including water and tourism) on a variety of ecosystems, such as river systems, grasslands and forestlands.

Industrialisation is broadly understood as the process by which an economy shifts from an agricultural to a manufacturing base during a period of sustained change and growth, eventually creating a higher standard of living (Ritzer 2007). The MA (2005) highlighted that many industrial products and commodities depend directly on ecosystem services, but that industrialisation can also impact on the environment. Industrialisation can cause increased production of greenhouse gases and pollution, and can intensify resource use. There is, therefore, an increasing focus on green industrial transformation.

Environmental regulation can help to trigger innovation, for example, through the development of new approaches to enable regulations to be met. The MA (2005) noted that declining ecosystem trends have sometimes been reduced by innovative, local responses, and the shape of the future will be impacted by innovations, including ones that have not yet been imagined. Therefore, innovation can positively impact on environment-human interactions and the achievement of the Global Goals through a variety of ways, for instance, via increasing the energy efficiency of production (Global Goal 8). At the same time, the environment can both inspire and lead to new innovations in products and processes (such as the development of new medicines; Global Goal 3).

1.10.3 Synthesis of developments in research, innovations and policies

Infrastructure

Green infrastructure

Green infrastructure refers to an interconnected network of natural and semi-natural elements capable of providing multiple functions and ecosystem services, encompassing positive ecological, economic and social benefits for humans and other species (Koc *et al.* 2016). This includes networks of green and blue spaces, green roofs and vertical greenery systems, as well as the use of ecosystems as a replacement for built infrastructure in order to combat issues like stormwater management, watercourse management, flood prevention, heat island effects and air pollution. The benefits of increased green infrastructure include the reduction of flood risk, improved air quality, better health and well-being (Global Goal 3), increased recreational and tourism opportunities (Global Goal 8), and the provision of habitat for wildlife (Global Goals 14 and 15). It is also cost-effective in comparison to conventional stormwater management and combined sewer overflow approaches (Jaffe 2011; Tao *et al.* 2014). Indeed, extensive green networks can be formed over time to create an encompassing 'city ecosystem' that supports the sustainable movement of people, rebuilds biodiversity and provides substantial climate change adaptation in urban environments (Global Goals 11 and 13) (Arup *et al.* 2014).

Water and energy infrastructure

Resilient infrastructure for managing water supplies and energy production are key components of countries infrastructure needs and essential for achieving Global Goals 6 and 7, and are discussed in those chapters. Agricultural (Goal 2) and health (Goal 3) also affect, and are affected by, irrigation and sanitation infrastructure.

Information and communications technology infrastructure

Information and communications technology (ICT) infrastructure is a growing issue – by the end of 2012, 34.3 per cent of the global population were internet users, and this is set to grow further (Whitehead *et al.* 2014). The main environment-human interaction related to ICT is the high energy consumption of data centres, which are the backbone of ICT networks (Global Goal 7). In 2007, the ICT industry was estimated to account for 2 per cent of global anthropogenic carbon dioxide emissions (Whitehead *et al.* 2014), and their carbon footprint is expected to grow by 12 per cent per year, thus impacting on global climate change (Global Goal 13) (Cook *et al.* 2011).

Transport infrastructure

Transport infrastructure includes the use of green infrastructure (such as rivers and natural harbours) and anthropogenic structures (such as roads, ports and airports), and can have significant impact on the environment. Globally, at least 25 million km of new roads are anticipated by 2050 – a 60 per cent increase in the total length of roads in comparison to 2010 (Laurance *et al.* 2014). Improved roads or other transportation can facilitate agricultural yield increases, but roads penetrating into wilderness or frontier areas are a major driver of habitat loss and fragmentation, wildfires, overhunting and other environmental degradation, often with irreversible impacts on ecosystems and threatening the livelihoods of indigenous groups (Espinosa *et al.* 2014). Impacts are most damaging in species- and carbon-rich ecosystems, such as tropical forests, particularly where few roads currently exist (Laurance *et al.* 2014). At the local and regional levels, a significant portion of freight transportation is carried out by trucks (Heavy Duty Vehicles [HDVs]), which emit a large amount of pollution. While transportation technologies and fuels have improved over the years, most trucks continue to run on diesel engines – a major source of polluting emissions (Global Goals 7 and 13) – and options for shifting to other energies, such as battery-powered electric vehicles, is limited (Sims *et al.* 2014). Although technological options may be limited currently, green road-freight transportation is a new concept that aims to reduce emissions through efficient vehicle routing and minimising total distance travelled (Demir *et al.* 2014).

Around 8.4 billion tonnes of cargo are transported by sea each year, equating to 90 per cent of global trade, and this is expected to triple by 2060 (Grech *et al.* 2013). Shipping is the most energy efficient means of transporting large volumes of cargo. However, the sheer scale of global shipping results in a variety of significant environmental impacts on the ocean (Global Goal 14), including air pollution, waste from ships, and the impacts of harbours and coastal infrastructure (GESAMP 2009). In terms of air pollution, around 15 per cent of global anthropogenic nitrogen oxides, and 5 to 8 per cent of global sulphur oxide emissions, are attributable to ocean-going ships because low-grade marine fuel oil contains 3,500 times more sulphur than road diesel (Viana *et al.* 2014). These shipping particulates also have direct impacts on human health (Global Goal 3) (Wan *et al.* 2016). Expanding harbours and coastal infrastructure can destroy coastal ecosystems, such as coral reefs. Dredging and port construction activities potentially affect, not only the site itself, but also surrounding areas, including due to release of contaminants and changes in sedimentation

dynamics (Foster *et al.* 2010). Effects may be immediate or develop over a longer timeframe, and may be temporary or permanent in nature (Foster *et al.* 2010). Global shipping also acts as a vector for aquatic invasive species (Global Goals 14 and 15).

Rising income and partially declining airfares have led to increased air travel, and the related construction and expansion of airports. Aviation requires less fixed infrastructures than terrestrial transportation; hence, it tends to have both a lower impact in terms of land requirements, and a relatively lower share of total lifecycle emissions for infrastructure (Sims *et al.* 2014).

Resilient infrastructure

For all infrastructure, there is a need to make it resilient to disasters. Since 2010, most of the USD 900 billion in economic loss caused by natural hazards has been due to damage to infrastructure (UN 2016a). The impacts of natural hazards on people and poverty, as well as the role of the environment in managing hazards, is outlined in Global Goal 1. Systematic approaches to the development and retrofitting of infrastructure is needed to minimise negative environmental impacts and trade-offs from its development, while maximising cost-effectiveness and resilience (UN 2016a). The estimated useful life of infrastructure ranges from 20 years for roads, to over 100 years for concrete bridges, sewer and water structures (UN 2016a). The effective operation and maintenance of infrastructure is needed over the full life of a project to assure that environmental safeguards are implemented (World Bank *et al.* 2007).

Industrialisation

Industrial activity currently causes large negative environmental impacts (Global Goals 8 and 12). Industrial wastewater can contain a number of different pollutants, including microbiological contaminants, industrial chemicals, metals, nutrients, suspended matter (particulates and sediments), pharmaceuticals and personal care products (Global Goal 6) (Palaniappan *et al.* 2010). Wastewater can also cause temperature changes through the discharge of warm cooling-water effluent (Palaniappan *et al.* 2010). Industry-related greenhouse gas emissions have continued to increase and are higher than emissions from other end-use sectors, representing just over 30 per cent of global emissions in 2010 (Global Goal 13) (Fischedick *et al.* 2014).

There is, therefore, a need to increase resource efficiency in production in order to decrease the environmental impacts of industrialization (Global Goal 8 and 12) (UNDESA 2014). Since resource inputs represent an important cost of production for industries, efficiency improvements can also be a significant lever for competitive advantage (UNDESA 2014). Investments in improving resource efficiency and recycling reduce the demand for energy, water and virgin resources (Global Goals 6, 7, 8 and 12), thus reducing the need to invest billions on new energy and water supply infrastructure (UNDESA 2014). For example, the International Energy Agency estimates that, if countries focused on boosting energy efficiency, they could not only provide a 10 per cent reduction in global energy demand by 2030, but also save USD 560 billion (UNDESA 2014).

In terms of greenhouse gas emissions, an absolute reduction in emissions from the industry sector will require deployment of a broad set of mitigation options beyond efficiency measures (Fischedick *et al.* 2014). The concept of the 'circular economy', in which resources are kept in use for as long as possible, extracting their maximum value, and their products and materials are recovered and regenerated afterwards, is receiving increasing attention worldwide as a potential means to transition towards decoupled economic growth and resource throughput (Global Goals 8 and 12) (Ghisellini *et al.* 2016).

Innovation

Innovation can be technological or non-technological. Types of technological innovation include product innovation (the introduction of new goods or services that may have improved characteristics or different uses), and process innovation (new or improved production or delivery methods, including changes in technique, equipment or software) (UNIDO 2015). Types of non-technological innovations include marketing innovation (changes in product design, packaging, placement, promotion or pricing), and organisational innovation (new business practices, workplace organisation or external relations) (UNIDO 2015). Innovation can happen in relation to all of the Global Goals; for example, it can be seen in agriculture (Global Goal 2), health (in terms of bio-innovations and new pharmaceuticals; Global Goal 3), water and sanitation technology (for example, reducing the use of solvents and toxic chemicals in industrial processes; Global Goal 6), energy efficiency (Global Goal 7), and production and consumption (Global Goal 12).

1.10.4 Knowledge and research gaps

Since the issues of decoupling economic growth and environmental impacts, and sustainable consumption and production, are so closely linked to the impacts of industrialisation, the knowledge and research gaps identified in Global Goals 8 and 12 also relate to Global Goal 9.

Additionally, further research and investigation is needed in the following areas:

Infrastructure and industrialisation

- Using life cycle perspectives to understand the environmental impacts of ICT infrastructure including looking at the interrelated nature of environmental impact in order to ensure impacts are not going unnoticed because of an operational focus, and looking at the most environmentally impacting parts of facilities beyond operational consumption (Whitehead *et al.* 2014).
- Transparency and analysis of carbon footprints across the ICT industry (Cook *et al.* 2011).
- The effects on species and ecosystems of industrial linear corridors, particularly in remote wilderness areas and developing countries, and potential mitigation measures (Latham *et al.* 2015).
- The infrastructure requirements for new low-carbon transport fuels, as well as the evolution of low-carbon transport and energy technologies (Sims *et al.* 2014).
- Systematic approaches and underlying methodologies to avoid double-counting greenhouse gas emissions in the industrial sector due to the many different ways of attributing emissions (Fischedick *et al.* 2014).
- The net impacts of different types of policies, the mitigation potential of linked policies (such as resource efficiency and energy efficiency policies), and policies as drivers of carbon-leakage effects (IPCC 2014c).

Innovation, in its very nature, is about developing new knowledge; therefore, innovation can help to fill all of the knowledge gaps highlighted in this report, so separate innovation gaps have not been identified.

1.10.5 Overview of networks and funding

There are a number of organisations that focus on specific aspects of infrastructure, including the Green Grid (TGG), the Green Infrastructure Investment Coalition (GIIC), and UNEPs Global Clean Ports Project; the International Civil Aviation Organisation (ICAO) has a Council Committee on Aviation Environmental Protection (CAEP). The networks and funders related to green growth and the green economy, such as the UN Partnership for Action on A Green Economy, also consider the environmental impacts of industrialisation. The United Nations Industrial Development Organisation (UNIDO) is the specialised agency of the UN that promotes industrial development for poverty reduction, inclusive globalisation and environmental sustainability. In 2015, UNIDO reported that its energy efficiency projects were funded to a total of USD 52.2 million in grants, with an additional USD 574 million in co-funding. In partnership with the European Commission, UNEPs Eco-Innovation Project (2012 to 2016) aimed to promote resource efficiency and eco-innovation through engaging small and medium-sized enterprises (SMEs), facilitating policy and technical conditions, and enabling systemic innovation and capacity building.

1.11 GLOBAL GOAL 10: REDUCE INEQUALITY WITHIN AND AMONG COUNTRIES

1.11.1 Summary of Global Goal

Global Goal 10 calls for a reduction in inequalities in income, as well as inequalities based on age, sex, disability, race, ethnicity, origin, religion, economic, or other status within a country. This Goal also addresses inequalities among countries, including those related to representation, migration and development assistance (UNECOSOC 2016b).

The aims of Global Goal 10 are also supported in other multilateral environmental agreements. The Convention on Biological Diversity (CBD) Aichi Biodiversity Target 14 states that, by 2020, the ecosystems that provide essential ecosystem services will be restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable (CBD 2010b). Other conventions also highlight the need to work with local and indigenous communities; for instance, the Ramsar Convention. The fair and equitable sharing of the benefits arising from genetic resources is highlighted in both the CBD and the International Treaty on Plant Genetic Resources for Food and Agriculture.

1.11.2 Overview of main environment-human interactions

Environmental inequality, is one form of inequality. It is identified as one of seven forms of inequality within the *World Social Science Report 2016: Challenging Inequalities: Pathways to a Just World* (ISSC *et al.* 2016), the other six being economic (income and wealth), political, social, cultural, spatial, and knowledge inequalities. The report highlights the importance of environmental inequalities, referring to differences and disparities in the quality of the environment to which individuals and groups have access (ISSC *et al.* 2016). In discussing such access, it refers to levels of environmental protection, access to natural resources and opportunities to benefit from their exploitation, exposure to pollution, and the risks of natural hazards and disasters. Environmental inequalities also covers capacities

to adapt to climate change and to adopt more sustainable ways of living, as well as the capacity to influence and shape decision-making relating to environmental issues (ISSC *et al.* 2016). In 2005, the Millennium Ecosystem Assessment noted that inequities are growing, and many people still do not have a sufficient supply of or access to ecosystem services (MA 2005).

All types of inequalities can have environmental impacts and affect prospects for sustainable environmental management, which can, in turn, impact on the supply of environmental services. Different aspects and forms of inequality interact. Horizontal or group-based inequalities, such as those based on ethnicity, can intersect with other inequalities and discriminations, such as those of space, gender and income, causing discrimination or marginalisation of particular people (ISSC *et al.* 2016). Income and wealth inequalities, such as an unequal access to natural resources, can occur both within a country, and between countries and across the globe (Shaheen 2014).

Overall, the environment-human links to inequalities have consequences for the achievement of virtually all the other Global Goals, but especially for the cross-cutting Global Goal challenge to 'leave no-one behind'.

1.11.3 Synthesis of developments in research, innovations and policies

Equity, environmental justice, inclusion, and the environment

There is evidence of rising inequalities within countries across the world (ISSC *et al.* 2016), as well as an increase in the concentration of economic and political power in the hands of elites. Currently, the richest 1 per cent of the global population has more wealth than the other 99 per cent (PwC 2016). This unequal distribution of wealth also holds within countries. In developing countries, the poorest half of the population often controls less than 10 per cent of its wealth; and, across OECD countries, the gap between the richest 10 per cent and the poorest 10 per cent is at a record level (PwC 2016).

Humans derive wide-ranging resources from the environment (Global Goals 14 and 15), including livelihoods (Global Goal 1), food (Global Goal 2), water (Global Goal 6) and traditional medicine (Global Goal 3); yet access to these resources is often unequal. Whether globally, nationally or locally, environmental and resource scarcities are rarely problems of overall availability, but rather of distribution amidst economic and political inequalities (Mehta 2010). Most of the world's arable land has now been privatised, and freshwater is increasingly becoming subject to market pricing (McMichael *et al.* 2008). Social inequalities can inhibit cooperation regarding the management of local, common or pooled resources, such as water or land (Berthe *et al.* 2015). Environmental inequalities in resource access and control, shaped by various forms of social, economic and gender inequality and discrimination, can create deprivation, driving downward spirals that can intensify inequalities even further.

Environmental justice has been defined as the fair treatment and meaningful involvement of all people, regardless of race, colour, national origin and income, with respect to the development, implementation and enforcement of environmental laws, regulations, and policies (US EPA 2016). There has been increasing literature and discussion on environmental justice, the addressing of which can support environmental equality. It is also an important framework for understanding conflicts over environmental conditions and sacred sites on indigenous lands (Global Goal 16) (Schlosberg *et al.* 2010).

Exposure and vulnerability to environmental stresses and shocks are affected by inequalities (Global Goal 1). As the literature on environmental justice has long made clear, the impacts of climate change (Global Goal 13), pollution and the degradation of land, vegetation, water and fisheries (Global Goals 14 and 15) are experienced differently according to class, ethnicity and location. More than one quarter of household income from livelihoods is derived from natural areas (Global Goal 1). Some groups rely on such areas much more than others; for example, a global overview shows that reliance on subsistence from forests was higher among households in the two lowest income quintiles, compared to those in the highest income quintile. Since poorer people can rely more on wild species (fish, animals and wild plants), declines in their stocks as population pressures and commercial activities intensify (McMichael *et al.* 2008), can make low income households poorer, increasing inequalities.

Other examples of environmental justice and inequality issues include the siting of toxic waste dumps and polluting industries, unequal enforcement of environmental laws, and the exclusion of certain groups of people from environmental decision-making (Schlosberg *et al.* 2010). In addition, limiting access of certain groups to natural resources through exclusionary practices (such as the privatisation of land and/or its resources through the creation of forestry concessions or protected areas) may jeopardise the livelihoods of those groups (Angelsen *et al.* 2014). Environmental justice is not limited by anthropogenic jurisdictions, but can cross borders; for instance, some European institutions dispose of electronic waste in countries like Ghana,

despite international conventions targeting this behaviour. Spatial inequality of this sort has environmental health impacts, including exposure to hazardous substances through air and groundwater (Global Goal 3) (Carmin *et al.* 2011).

In contrast, environmental resource use does have the potential to decrease inequalities. Mining and fossil fuel extraction can provide jobs and fund government investments in development. Goderis and Malone (2008) found that natural resource booms, especially mineral booms, lower inequality in the year of the boom. They also showed, however, that this effect gradually diminishes over time, until inequality returns to its pre-boom level.

Equitable sharing of benefits from genetic resources

The equitable sharing of genetic resources is an environmental equality issue that has had greater attention in recent years (Global Goal 15). Genetic resources are used around the world, yet the distribution of the capacity to use them, and the amount of resources between countries, is unequal. It is suggested that unequal interdependence on these resources can either be a threat to national sovereignty (Global Goal 16), or an opportunity for collaboration.

Effects of inequalities on the environment

The ecological footprint in more equitable countries tend to be much smaller than in more inequitable countries (Islam 2015). Economic inequality is positively correlated with emissions scores (Global Goal 7), air pollution, urban water pollution (Global Goal 6), the disappearance of forest and the number of species under threat (Global Goal 15) (Islam 2015). Economic inequality was negatively correlated with per capita carbon dioxide emissions, industrial gas emissions in China, particular pollutants, soil depletion and organic water pollution (Berthe *et al.* 2015). Recent evidence also suggests that greater income inequality is associated with a greater loss of biodiversity – for every 1 per cent rise in in the Gini ratio, there is a 2 per cent rise in the number of threatened vertebrate and plant species (Islam 2015).

Equality and environmental impact may correlate for a number of different reasons. Economic, social and spatial inequalities, and discrimination against certain groups, can push those at the bottom into unsustainable practices that worsen environmental degradation, inequality and unsustainability. For instance, when land and water grabs linked to elite-driven commercial developments dispossess indigenous people onto marginal lands, they may be forced to 'mine' soils and vegetation unsustainably in order to subsist. Environmental inequalities can also work directly against sustainability; for example, when people deprived of secure tenure over natural resources lack the incentives and abilities to conserve them for the future. Furthermore, inequalities in wealth, privilege and power have enabled those at the top (wealthy businesses and consumers) to pollute and degrade environments with impunity (ISSC *et al.* 2016).

Community behaviour may also be influenced by inequality, the reduction of which, may promote the protection of environmental resources through collective behaviours (Islam 2015). Challenges in collective management of common property resources, caused by inequality, can cause overexploitation of natural resources. Research shows that a number of factors may aid in the effective management of these resources: (i) definable boundaries of the resources, (ii) high dependence on the resources by communities may increase likelihood of management, (iii) a small and stable community with social norms and networks, (iv) community-based rules and enforcement (Islam 2015). Nationally, unequal societies can be less able to address sustainability challenges in the long term, as their ability to form a common commitments to change can be compromised (Wilkinson *et al.* 2010). Inequalities can also drive competition for status within communities, which, if linked to material consumption, may drive unsustainable practices and lifestyles.

At the international level, inequalities in the consumption of natural resources have been shown to hinder efforts regarding the protection of national and global environmental resources. It is well reported in the literature that richer countries consume more, and have a higher ecological footprint (including waste production), than poorer countries. Even among richer countries, there is a difference in ecological footprint between more and less equal countries. These inequalities can hinder environmental management – the action required to address climate change, for instance, requires cooperation across all scales (Global Goal 13). Indeed, it has been suggested that high levels of inequality obstruct ideas around a common purpose and set of resources, potentially undermining and preventing the trusting relationships required to manage resources effectively (Islam 2015).

Environment, health and inequalities

The interactions between health inequalities and the environment are relatively well established, including links with air quality, exposure to toxins and waste. The effects of ambient and household air quality and pollution (Global Goal 3) are often a result of burning natural resources, and are unequal in distribution (WHO 2010a). In addition, less affluent and poorer populations are more

affected by inadequate housing conditions, and the environmental burdens associated with their surroundings, than richer populations, although few adequate studies were found to explore this in detail (WHO 2010a). Studies in children and adolescents show that communities living in adverse social circumstances suffer differential exposure to environmental toxins, and have fewer opportunities for physical activity (WHO 2010a). Research has also shown that exposure to waste is different between socioeconomic classes; in the USA, waste facilities are disproportionately located in areas with low income and a higher proportion of ethnic minorities, which has been shown to adversely affect human health (WHO 2010a). In the UK, a study showed that coastal flood risk affects low-income communities in particular (WHO 2010a). Differences in good water, hygiene and sanitation are also unevenly distributed (Global Goal 6).

Overall, these differential health risks reflect the wider issue of access to global and local public goods. The relation of environmental impoverishment to health risks and inequalities is complex. Environmental degradation impairs health, while health deficits (for example, malnutrition) can amplify environmental mismanagement (McMichael *et al.* 2008). Policies should, therefore, pay particular attention to the health inequalities that flow from unequal access to environmental resources.

1.11.4 Knowledge and research gaps

Environmental justice research is needed to explore:

- The relationships between the distribution of environmental burdens and multiple intersecting inequalities (economic, race, spatial) as they affect particular groups.
- The environmental justice implications of climate change impacts and proposed solutions (Mohai *et al.* 2009).
- The potential role of green technologies and green businesses in reducing unequal exposures to risks (Mohai *et al.* 2009).
- Cases where 'just sustainability' (the combination of social justice and environmental sustainability) has been achieved in practice, including through community initiatives, and to explore how these can be scaled up and supported in policy.

Economic inequality and environmental conditions research is needed that:

- Interrogate the mechanisms behind the correlations between economic inequality and environmental conditions (including aspects of biodiversity, soil quality and pollution) and to inform policy (Islam 2015).
- Use longer-term exploratory case studies and longitudinal research to understand cumulative environmental impacts and inequalities, while tracking the effects of intersecting inequalities on environmental outcomes in different urban and rural environments (Stephens *et al.* 2007).
- Develop a further understanding of environmental inequality and public health (Brulle *et al.* 2006), particularly with regards to the relationship between gender and air quality in children and adults (WHO).
- Assess the effectiveness of interventions that reduce inequalities from environmental exposure (WHO 2010a).
- Investigate the interactions between environmental hazards, socioeconomic position, and community stressors (WHO 2010a).

Knowledge on inequality-environment linkages also needs to be informed by a better understanding of the inequalities themselves. The recent *Challenging Inequalities* report (ISSC *et al.* 2016) identifies key gaps and a research agenda with the following priorities:

- Research on inequality, and processes of social inclusion and exclusion, in those places most affected by them (between 1992 and 2013, more than 80 per cent of publications on inequality came from Europe and North America).
- Improve ability to assess, measure and compare the dimensions of inequality over time and across the world.
- Deepen understanding of diverse experiences of inequality, especially by people in marginalised urban and rural settings.
- Deepen understanding of how multiple inequalities are created, maintained and reproduced.
- Deepen understanding of how local and global forms of inequality connect and interact.
- Research the policy changes and forms of social and political action that have enabled some countries to move towards greater equality during certain periods, learning lessons from these.
- Support cross-cutting syntheses and theory on inequality and equality.
- Overview of networks and funding

A number of networks work towards collating the data needed to achieve Global Goal 10, such as the Environmental Justice Atlas, which documents social conflict associated with environmental issues (and was supported by the European Commission 2011 to 2015). Another example is the World Inequality Database on Education (WIDE), set up by UNESCO. Non-governmental organisations (NGOs) also exist, such as the Environmental Justice Foundation (EJF), which works internationally to protect the environment and defend human rights.

1.12 GLOBAL GOAL 11: MAKE CITIES INCLUSIVE, SAFE, RESILIENT AND SUSTAINABLE

1.12.1 Summary of Global Goal

The overall aim of Global Goal 11 is to make cities and human settlements inclusive, safe, resilient and sustainable. Specifically, it strives to ensure access for all to adequate, safe and affordable housing and basic services and to upgrade slums; provide access to sustainable transport systems and improve road safety; enhance inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management; strengthen efforts to protect and safeguard the world's cultural and natural heritage; reduce the number of deaths and economic losses caused by disasters; reduce the adverse per capita environmental impact of cities, focusing particularly on air quality and waste management; and provide universal access to green and public spaces, in particular for women, children, older persons and persons with disabilities.

The concern and problems associated with urban areas and the environment have placed such issues high on the agenda of many bilateral and multilateral meetings. There are several multilateral environment agreements that are specifically directed at cities. For instance, Local Agenda 21, developed at the Rio Earth Summit in 1992, is a strategy and action programme for implementing sustainable development at a local level. At the 2010 Convention on Biological Diversity (CBD) Conference of the Parties, 193 governments agreed a Plan of Action on Subnational Governments, Cities and Other Local Authorities for Biodiversity (2011 to 2020) (CBD 2010b). This Plan outlines ways in which national governments can support the contributions of their local and subnational counterparts, including cities, in achieving the Aichi Biodiversity Targets.

1.12.2 Overview of main environment-human interactions

At a time when the majority of the world's population lives in cities, and the bulk of economic activity is concentrated in urban areas, cities must be given priority as the building blocks of a global, socially inclusive, sustainable economy. Indeed, by 2030, it is projected that 6 out of 10 people will be urban dwellers. Although cities are efficient users of land, they have footprints that extend far beyond their authority boundaries. At present, the world's cities occupy just 2 per cent of the Earth's land, but account for 60 to 80 per cent of energy consumption (Global Goal 7), and 40 to 70 per cent of carbon emissions, ultimately, impacting on global climate change (Global Goal 13). Indeed, for every 10 per cent increase in urban sprawl, there is a 6 per cent increase in per capita carbon dioxide emissions and a 10 per cent increase in per capita hazardous pollution (UNECOSOC 2016b).

Despite the potential of well-managed cities and other human settlements to be incubators for innovation and ingenuity, and key drivers of sustainable development, urban areas are hot spots that drive environmental change at multiple scales. Their material demands of production and human consumption alter land use and cover, biodiversity, and hydrosystems locally and regionally, and urban waste discharge affects biogeochemical cycles and climate on local and global scales (Global Goals 14, 15, 6, 13). This illustrates the important interlinkages across the Global Goals and their targets.

1.12.3 Synthesis of developments in research, innovations and policies

Urban water supplies

Water depletion is a problem in many urbanised water basins. Since 1950, cities have increased their water usage five-fold, not only through population growth, but through increased per capita demand (Arup *et al.* 2014). At present, half of all cities with populations greater than 100,000 are located in water-scarce basins. Within these basins, agricultural water consumption accounts for more than 90 per cent of all freshwater depletions (Global Goals 2, 6) (Richter 2013). Meanwhile, there is increased decoupling of urban and rural systems, and a diminishing holistic consideration of the global water cycle. In planning future sustainable urban water programmes, we must recognise that cities don't exist in isolation (Arup *et al.* 2014). This is illustrated by the 100 largest cities in the world, which constitute less than 1 per cent of global terrestrial area, but rely on more than 12 per cent of the Earth's land for their source watersheds – i.e. rivers, forests and other ecosystems from which their water originates (McDonald 2014). As such, the overextraction of aquifers is happening in many densely populated areas. In particular, the extraction of fossil water from deep aquifers is unsustainable as they will not be refilled on human timescales (GIWA 2006). Future trends in urban water consumption patterns will likely be determined by changes in population concentration, per capita water use, climate, and the proportion of water retained for the production of instream ecosystem services (Jenerette *et al.* 2006).

When it comes to water supplies, cities face twin challenges: water that is both scarce and polluted (McDonald 2014). Indeed, urban settlements are

the main source of point-source water pollution. At present, more than 80 per cent of sewage in developing countries is discharged untreated, polluting rivers, lakes and coastal areas (Global Goals 14, 15). Even in some developed countries, treatment of urban wastewater is far from satisfactory, and is particularly hazardous when mixed with untreated industrial waste (Global Goal 9) (WWAP 2015).

Many large cities have no treatment plants, or the plants they do have, quickly become undersized as urban population growth outpaces investments (WWAP 2015). Indeed, a World Health Organization-UN Children's Fund Joint Monitoring Programme (WHO-UNICEF 2010) report indicates that, in 2008, around 84 per cent of urban residents in Sub-Saharan Africa had no onsite sanitation technologies; thus constituting a major human health risk in this region (Global Goal 3). In Europe, the flow of nutrients into coastal waters is reducing ecosystem productivity and creating anoxic dead zones (Bahri 2012). Projections indicate that the increasing number of urban dwellers will likely increase nutrient pollution in the future (McDonald 2014).

By using the market-based mechanism of Payment for Environmental Services (PES), many cities have safeguarded the natural water purification services of their watersheds (Global Goal 6), thereby avoiding expensive treatment systems. Despite PES schemes being controversial, they have shown to mitigate the risks posed to watersheds by linking the payment for hydrological services to water consumers and investing the resulting funds into conservation, restoration and land acquisition. Some authors recommend urban-rural partnerships, under which cities work with farmers to implement irrigation conservation measures, thus freeing up water for ecological restoration and use by cities (Richter 2013). Unfortunately, in many parts of the world, wastewater regulation is complicated by overlapping lines of authority between health, agriculture, and water supply and sanitation agencies (Bahri 2012). The majority of PES schemes are in South America (Buric *et al.* 2011).

Municipal solid waste

Today, there are around 3 billion urban residents generating around 1.3 billion tonnes of municipal solid waste (MSW) per year. By 2025, the numbers of city dwellers will likely increase to around 4.5 billion residents, producing 2.2 billion tonnes of waste each year. Poorly managed waste has enormous impacts on health, the local and global environment, and the economy (Global Goals 3, 8). The results are often seen in downstream costs, which are higher than the initial price of appropriate management would have been (Hoornweg *et al.* 2012).

Generation rates of MSW are influenced by factors like economic development, the degree of industrialisation (Global Goal 9), public habits and local climate. Generally, as disposable incomes and living standards increase, consumption of goods and services correspondingly increases (Global Goal 12), as does the amount of waste generated. Currently, urban residents produce about twice as much waste as their rural counterparts. In low- and middle-income countries, MSW is often dumped in low-lying areas and land adjacent to informal settlements. Such situations are often coupled with a lack of enforced regulations, enabling potentially infectious medical and hazardous waste to be mixed with MSW (Global Goal 3). In turn, waste pickers are exposed to diseases and hazardous waste. There is also a strong correlation between urban solid waste generation rates and greenhouse gas emissions. This link is similar in other urban inputs and outputs, such as wastewater and total energy use (Global Goal 7) (Hoornweg *et al.* 2012).

Electric and electronic waste (EEW) is predominately generated in highly urbanised areas in Organisation for Economic Co-operation and Development (OECD) countries. Although the results of estimation studies vary widely, it is thought that 20 to 50 million tonnes of EEW is discarded annually, and this amount is continuing to grow. The potential negative health and environmental consequences of incorrectly handled and treated EEW are well documented in the literature. Furthermore, when the valuable metals (such as copper, aluminium, gold) used in electronic goods are not recovered, the resulting mining, manufacturing and energy use needed for further production can result in significant environmental damage (Ongondo *et al.* 2011).

Moving towards modern MSW disposal systems has generally followed a step-by-step process: firstly, phasing out uncontrolled disposal, then introducing, and gradually increasing, environmental standards for disposal facilities. In the process, the control of water pollution and methane emissions from sanitary landfills, and air pollution from incinerators, is also addressed. Attention in high-income countries may now be moving on to other aspects, but many cities in low- and middle-income countries are still working on phasing out open dumps and establishing controlled disposal (UN-Habitat 2011).

Sustainable transport

Transport activity, a key component of economic development and human welfare, is increasing around the world as economies grow (Global Goal 8). The most pressing problems associated with this increasing activity are traffic fatalities and injuries, congestion, air pollution and petroleum

dependence. These problems are especially acute in the most rapidly growing economies of the developing world. Transport predominantly relies on a single fossil resource – petroleum – which supplies 95 per cent of the total energy used by transport globally. In 2014, transport was responsible for 23 per cent of world energy-related greenhouse gas emissions, with about three-quarters coming from road vehicles. Over the past decade, transport's greenhouse gas emissions have increased at a faster rate than any other energy using sector (Global Goals 7, 13) (Bruckner *et al.* 2014).

The current trend in urban development for the increasing use of private vehicles generates many social and economic costs through air pollution, chronic congestion, energy consumption, carbon emissions, traffic accidents and severance of communities (Global Goals 8, 13, 3, 9). These costs can total more than 10 per cent of a country's Gross Domestic Product (GDP) in some circumstances (Dalkmann *et al.* 2012). Urban travel currently constitutes more than 60 per cent of all kilometres travelled globally, and is the largest single source of global transport-related emissions, and the largest local source of urban air pollution (WHO *et al.* 2016).

In practice, cities can reduce pollution and travel times in two ways: (i) by promoting compact, mixed-use urban development to reduce trip distances; or (ii) by shifting travel either to modes with higher passenger occupancy (such as public transit or carpooling), or to non-motorised modes. These policies share the aim of reducing the number of vehicle trips without seeking to affect the number of person trips (Dudata 2013). In developing countries, a high proportion of the population walk or use non-motorised transport, particularly for journeys less than 5 to 8 km. However, accessible and safe infrastructure for non-motorised transport is lacking in most cities in developing countries. In comparison, cities in developed countries that have implemented policies and infrastructure projects to promote citywide cycling have reported significant safety benefits (for instance, Copenhagen and New York) (Dudata 2013).

A survey of climate change plans for 30 cities found that the most common climate change mitigation actions for transport included: the development of public transport systems (including bus rapid transit systems); the implementation of cleaner technologies; the promotion of non-motorised transport; and increased public awareness campaigns. Significantly, cities are also providing arenas for the experimentation and promotion of new technologies (Global Goal 9) (CDP 2013). In developing countries, however, the trend is still largely towards the expansion of infrastructure for private motor vehicles (UN-Habitat 2011).

Currently, three types of policies and measures to control the externalities of transportation exist: (i) fiscal policies, such as fuel and emission taxes, congestion charges and subsidies for clean fuel and vehicles, and public transportation; (ii) regulatory policies, such as standards for fuel economy, emissions and fuel quality; and (iii) planning and investment measures, such as land-use or urban planning and infrastructure investment. There is a general consensus in the literature that integration of a suite of various policies and measures is necessary to effectively reduce the externalities of urban road transportation. Local air pollution is the priority concern for many developing countries; all told, air pollution is estimated to cause 800,000 deaths in urban areas every year (WB 2014), through its effects on heart disease, strokes, respiratory infections and lung cancer (Global Goal 3). While the different risk factors that affect the poor are not always clear, this segment of the population appear to be at more risk from all forms of air pollution (UN-Habitat). Therefore, local emission standards would be the most appropriate measures in these countries. Coupled with infrastructure investments, such as the expansion of roads, these measures could help reduce congestion, but they will not reduce fuel consumption and emissions (Timilsina *et al.* 2011).

Sustainable urbanisation

Unplanned or inadequately managed urban expansion leads to rapid sprawl, pollution, and environmental degradation, together with unsustainable production and consumption patterns (Goal 12). The energy requirements for urban transport are strongly influenced by the density and spatial structure of the built environment (Bruckner *et al.* 2014). This phenomenon is illustrated by a recent analysis which suggests a negative relationship between commuting distance and residential density. In fact, the commuting-related carbon dioxide emissions associated with high-density cities (more than 2500 addresses per km^2) are about half the emissions from low-density villages (less than 500 addresses per km^2) (Grazi *et al.* 2008).

For more than a century, there has been a trend of decreasing urban density in the developed world as cities accommodate motorised transport and build low-density housing on the outskirts. This results in more complex journeys and makes the provision of cost-effective public transport away from city centres more difficult. Despite substantial road building to ensure effective transportation, congestion has been getting worse and average traffic speeds have been declining. Congestion affects all road users, but the poorer

segments of society are affected the greatest, and poor people frequently have to walk or travel in slow-moving, overcrowded buses (UN-Habitat 2011). Higher-density residential neighbourhoods, with shorter intra-urban distances, are associated with more walking and cycling (WHO *et al.* 2016). However, access to basic facilities (water, schools, markets, clinics) varies substantially between locations, with poor areas generally at a disadvantage (Global Goals 1, 10).

During the past 10 to 20 years, high-income countries have been rediscovering the value of recycling as an integral part of their waste (and resource) management systems, and have invested heavily in both physical infrastructure and communication strategies to increase recycling rates. Many developing- and transitional-country cities still have an active, informal sector and microenterprise recycling, reuse and repair systems; this often achieves recycling and recovery rates comparable to those in developed countries (Lotze *et al.* 2011). Indeed, MSW can represent a considerable potential resource. In recent years, the global market for recyclables has increased significantly. The world market for post-consumer scrap metal generates at least USD 30 billion per year (UN-Habitat 2011). Producing new products with secondary materials can save significant energy (Global Goal 7). For example, producing aluminium from recycled aluminium requires 95 per cent less energy than producing it from virgin materials (Hoornweg *et al.* 2012).

Access to green spaces

By simultaneously making older, and typically low-income and/or industrial areas, of existing cities more liveable and attractive, urban-greening projects can set off gentrification, dramatically altering housing opportunities and the commercial and retail infrastructure that supports lower-income communities. This paradoxical effect has been variously termed 'ecological gentrification', 'green gentrification', 'environmental gentrification' and 'eco-gentrification' (Wolch *et al.* 2014)

In many countries, private gardens are a major component of urban green space and can provide considerable biodiversity benefits (Global Goal 15). Gardens and adjacent habitats form interconnected networks; indeed, a landscape ecology framework is necessary to understand the relationship between the spatial configuration of garden patches and their constituent biodiversity (Goddard *et al.* 2010).

Residents of large cities often live in single- or limited-use neighbourhoods, with long distances to work and a lack of green spaces and other essentials of daily living. Residents of these cities often fall into sedentary behaviours, suffer poor nutrition and mental health issues, and become susceptible to precursors of non-communicable diseases (Global Goal 3) (WHO *et al.* 2016).

Water-related disasters

The transformation of natural land surfaces into impervious surfaces, such as streets, parking lots and buildings, blocks rainwater and snowmelt from reaching the soil. It also increases the flow velocity of water, and carries pollutants into receiving water systems, degrading water quality (Global Goal 6). This urban drainage effect increases the frequency of flash floods, causing casualties and infrastructure damage (Global Goals 3, 9) (Björklund *et al.* 2009).

Due to global climate change, the number of typhoons and cyclones has been increasing, as have the number and expanse of drought-affected areas. Densely populated urban areas, where adaptive capacity is relatively weak, are especially at risk. Water-related disaster-risk management, and the expansion of facilities for water-resources development, water supply, irrigation, wastewater treatment and recycling, need to be promoted with community participation. In urban areas, comprehensive and collective efforts are needed to manage water-related disasters within the context of integrated water-resources management, and to optimise the use of limited financial resources and capacities (Global Goals 6, 13). Municipal water utilities need to assess their stormwater and sewer systems capacities due to intensifying storms and increased rainfall associated with climate change (Arup *et al.* 2014).

1.12.4 Knowledge and research gaps

Further research and investigation is needed in the following areas:

Environmental impact of urbanisation

- Aquifers and transboundary aquifers (GIWA 2006).
- Waste disposal data at the national level and consistent methodologies and definitions for each waste disposal category (Hoornweg *et al.* 2012).

Sustainable transport

- Mitigation potential in the transport sector to 2030, including research and development outcomes in biomass fuel production and its sustainability, and battery longevity, cost and specific energy (Bruckner *et al.* 2014).
- Efficiency improvements in rail transport, for example reduced aerodynamic drag, lower train weight, regenerative breaking and higher efficiency propulsion systems (Bruckner *et al.* 2014).
- Accounting for autonomous vehicles in city transport planning (P. Guthrie, pers. comm.).

Sustainable urbanisation

- Resource flows of cities, including the current status of material flows, the social and technical organisation of utilities and infrastructures, the pressures and drivers in individual cities, and the existing or potential socio-technical capability for shaping resource flows (UNEP 2013a).
- Analytical frameworks that account for quantitative and qualitative assessments of all influencing factors in selecting policy instruments for reducing negative externalities from urban transportation (Hoornweg *et al.* 2012).

Access to green spaces

- Land-use decisions and ecological processes (including in private gardens) important for enhancing native, urban biodiversity (Goddard *et al.* 2010).

1.12.5 Overview of networks and funding

There are range of organisations and networks involved in the promotion of sustainable cities. The prominent intergovernmental initiatives include: the European Union (EU) European Initiative on Smart Cities and Communities, which is providing USD 420 million to European regions for boosting smart, sustainable solutions for cities (2012 to 2020); and the Multilateral Development Bank Working Group on Sustainable Transport, which recently agreed to provide more than USD 175 billion of loans and grants for transport in developing countries (2012 to 2022). Other networks include the Major International City Networks and Initiatives on Climate Change, which is an umbrella group for many ongoing partnerships and initiatives. Non-governmental organisations (NGOs) working in this area include the Sustainable Cities Collective and Sustainable Cities International.

1.13 GLOBAL GOAL 12: ENSURE SUSTAINABLE CONSUMPTION AND PRODUCTION PATTERNS

1.13.1 Summary of Global Goal

Global Goal 12 calls for consumption and production patterns to become sustainable, while recognising economic growth and development require the production of goods and services that improve quality of life (UNECOSOC 2016b). Sustainable consumption and production is about promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs, and a better quality of life for all. At the same time, it should allow for sustainable growth and development. Its implementation helps to achieve overall development plans, reduce future economic, environmental and social costs, strengthen economic competitiveness, and reduce poverty.

The 10-year Framework of Programmes (10YFP) on Sustainable Consumption and Production patterns was adopted by countries at the Rio+20 Conference (UNCSD 2012). It aims to develop voluntary sector-based sustainable consumption and production programmes within a 10-year timeframe, thus contributing to meeting the aims and principles of the framework. A number of other multilateral environmental agreements also address specific aspects of sustainable production and consumption. For example, Goal B of the Strategic Plan for Biodiversity 2011-2020 is to reduce the direct pressures on biodiversity and promote sustainable use. This is further articulated in, for example, Aichi Biodiversity Target 7 By 2020, areas under agriculture, aquaculture and forestry will be managed sustainably, ensuring the conservation of biodiversity (CBD 2010b). The trade of endangered species and, in effect, their sustainable use is addressed by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Several multilateral environmental agreements also specifically address chemical and waste management, including the Vienna Convention and its Montreal Protocol on Substances that Deplete the Ozone Layer (UNEP 2016g), the Basel Convention on Hazardous Waste, the Rotterdam Convention on the Prior Informed Consent Procedure, and the new Minimata Convention on Mercury.

1.13.2 Overview of main environment-human interactions

Sustainable consumption and production minimises the negative effects of consumption and production, including impacts on the environment, such as the generation of waste and pollution, and the direct use of natural resources (such as land, timber, fish, minerals and fossil fuels). Sustainable consumption can contribute to resource efficiency and the decoupling of economic growth from environmental degradation and resource use (Global Goal 8).

The Millennium Ecosystem Assessment (2005) noted that consumption of ecosystem services, which is unsustainable in many cases, will continue to grow. Although consumption of ecosystem services is slowly starting to be being decoupled from development and economic growth, there is a need for measures to reduce aggregate consumption of unsustainably managed ecosystem services (MA 2005). Since the MA, there have been developments in green growth, the green economy and economic development

(Global Goal 8), in general, which are intrinsically linked to sustainable consumption and production.

1.13.3 Synthesis of developments in research, innovations and policies

Sustainable consumption and production and green growth

Sustainable consumption and production is closely linked to the green growth agenda (Global Goal 8). This agenda is focused on maintaining natural capital and, therefore, productivity and capacity of our planet to meet human needs and sustain economic activities (UNEP 2015g). It has been suggested that the monitoring of Global Goal 12 could be supported through the new System of Environmental-Economic Accounting (SEEA) framework (Global Goal 8) (Steinbach *et al.* 2016). In terms of consumption, in most countries, household consumption determines 60 per cent or more of the life cycle impacts of final consumption (Hertwich *et al.* 2010). It should also be noted that, due to trade, impacts driven by consumption in developed countries are, in part, translocated to countries where production takes place (Global Goal 10); the 'circular economy' (in which resources are kept in use for as long as possible, extracting their maximum value, and their products and materials are recovered and regenerated afterwards) and related issues are also discussed in Global Goal 9.

Sustainable consumption and production across sectors

There has been a large amount of research on sustainable consumption and production, including the establishment of a new scientific journal in 2015, published by the Institution of Chemical Engineers (IChemE) in partnership with Elsevier – *Sustainable Consumption and Production*. Developments in sustainable consumption and production research, innovation and policy cover a range of issues, such as: life cycle assessments; certification and standards; no net loss policies; carbon and water footprinting; consumer preferences and attitudes; supply chain management; and sustainable procurement.

These developments are being addressed in a range of sectors, including chemical, construction and building, energy, financial, food, health, manufacturing, extractive, retail, tourism, transport, waste and water. With regard to the different sectors, a UNEP review of the environmental impacts of consumption and production identified that a wealth of studies from different perspectives (production, consumption and materials) and that these studies together provide a consistent overall picture (Hertwich *et al.* 2010). Agriculture and food consumption are identified as one of the most important drivers of environmental change in relation to habitat change, climate change, water use and toxic emissions. The use of fossil fuels for heating, transportation, metal refining and the production of manufactured goods has also been identified as being of critical importance, causing the depletion of natural resources, climate change, and a wide range of emissions-related impacts. Such environmental changes highlight the significant linkages between sustainable consumption and energy provision (Global Goal 7), food (Global Goals 2 and 14), climate change (Global Goal 13), life on land (Global Goal 15), and water (Global Goal 6). The UNEP report (Hertwich *et al.* 2010) showed that, from a production processes perspective, fisheries were also one of the main causes of environmental change (Global Goal 14). In terms of material use, priorities should be focused on plastic production (Hertwich *et al.* 2010).

Sustainable consumption and production in specific sectors—food, energy, water and tourism

Within each individual sector, there is a large body of research focusing on the sustainability of that sector, as well as developments in policy and innovation. For instance, there is contrasting evidence on the additional land available for cultivation (agricultural sector), the rate of deforestation (forestry sector), and how much additional freshwater is available for sustainable use (water sector) (Myers *et al.* 2009). Discussion of the specific impacts of sustainable production and consumption in relation to food production, water supply and energy provision, including key impacts on water and climate change, are discussed within the relevant sections of this study (Global Goals 2, 6, 7, 13 and 14). In terms of sustainable food production, the issue of food waste has attracted attention within research and policy communities (see section on waste below). Sustainable tourism, including nature-based tourism, has also been highlighted as of particular importance to this Global Goal, creating jobs and promoting local culture and products (Global Goal 8).

Sustainable consumption and production in specific sectors—mining

Mining involves extracting resources from the environment, it can have negative impacts on the environment (e.g. through atmospheric dust, (Csavina *et al.* 2012)), and can have knock on impacts on human health (e.g. from mercury exposure (Gibb *et al.* 2014)). However, sustainable mining has attract a large body of research and innovation which is documented in a number of specialised journals such as the Journal of Sustainable Mining. A review of the relationship between mining and the Global Goals by the World Economic Forum (Lewis *et al.* 2016) showed that the mining industry can positively

contribute to all 17 Goals, but, to do so, it must significantly increase its engagement, partnership and dialogue with other industry sectors, government, civil society and local communities. Certification schemes are increasingly being used by minerals companies as a tool to demonstrate that they are operating responsibly (WEF 2015b). Many mining companies have initiated, or participate in, a number of issue-specific and more broad-based assurance systems, such as: the International Cyanide Management Code (ICMC); Towards Sustainable Mining (TSM), a Mining Association of Canada programme; and the ICMM Sustainable Development Framework. However, it has also been suggested that "meaningful and reliable standardised disclosures of contributions to sustainability are unlikely to emerge any time soon" (Fonseca *et al.* 2014). More systematic consideration of site-level performance, scenario building and legacy effects are needed in the frameworks of mining corporations if their reports are to provide meaningful and accurate information about sustainability progress (Fonseca *et al.* 2014).

In a survey by the World Economic Forum (WEF 2015b), which was focused on perceptions regarding current initiatives, regulation was cited as the main driver of responsible mining, but community accountability, downstream pressure, reputational issues associated with environmental performance, and the cost of conflict were also highlighted as important (Lewis *et al.* 2016). Awareness of new initiatives was high, but respondents placed greater value on long-standing, established initiatives, particularly those linked to credible institutions. The proliferation of initiatives to address assurance and certification issues, and the lack of clarity of synergies between initiatives, make it challenging for mining companies to decide which ones to adopt; indeed, this makes it seem that focusing on sustainability is more costly to implement. Respondents emphasised the value of prioritisation and consolidation with 96 per cent agreeing that there is potential to create linkages or efficiencies between voluntary initiatives (Lewis *et al.* 2016).

The sustainability and associated processing impacts of rare earth elements (such as lanthanum and lutetium) is a growing consideration as there is increasing demand for their use in renewable energy technologies, such as wind turbines, batteries, catalysts and electric cars (Haque *et al.* 2014) . Haque et al. (2014) also noted that water and energy consumption associated with the full life cycle of rare earth elements is significantly higher compared to other, traditionally used metals.

Waste and pollution

Emissions are identified as one of the key impacts of unsustainable production and consumption (Hertwich *et al.* 2010). Impacts from emissions include climate change from greenhouse gas emissions, eutrophication from the release of nitrogen and phosphorus, and human and ecotoxic effects caused by air pollution and other toxic emissions.

Waste covers a very wide spectrum of discarded materials from municipal, and electrical and electronic waste, to industrial and agricultural waste (Global Goals 2, 6 and 7) (PwC 2016). Reducing waste both improves resource use efficiency, and reduces toxic emissions. The amount of just one waste category, municipal waste, is projected to rise from 3.5 million tonnes per day in 2010, to more than 6 million tonnes per day by 2025, and tripling to 11 million tonnes per day by 2100 (PwC 2016). Of all the food produced in the world for human consumption every year, roughly one-third (1.3 billion tonnes) gets lost or wasted (PwC 2016). It should also be noted that, when food becomes waste (Global Goal 2), inputs in the production process are also wasted, including chemicals, such as fertilisers and pesticides, and the fuel used for its transportation. In addition, rotting food creates yet more harmful methane, a potent greenhouse gas (PwC 2016). The ultimate goal is to create a circular economy, which is producing no waste and no pollution by reusing, recycling and repairing products and materials, as well as designing things to last longer, and finding more sustainable business models.

In 2015, the United Nations (UN) identified e-waste as "one of the fastest-growing waste streams" on the planet, leaving a toxic legacy of heavy metals and chemicals in countries like India and China where recycling factories recover e-waste materials. Globally, an estimated 41.8 millon tonnes of e-waste was discarded in 2014, a figure predicted to rise to 50 million tonnes by 2018 (PwC 2016).

Achieving sustainable production and consumption

An OECD (2008b) report on promoting sustainable consumption highlights the range of approaches that have been used, including: taxes and charges, and subsidies and incentives; understanding consumer behaviour; communications campaigns, advertising and education; corporate reporting, public procurement, and institutionalising sustainable consumption; combining policy instruments; standards and mandatory labels, and voluntary labelling; and certification, standards and voluntary initiatives (see above for mining related discussion). Increasing emphasis is also being

placed on life cycle assessments (UNEP 2011a; UNEP *et al.* 2011).

Across different sectors, innovation in standards and certification schemes has included emphasis on the 'no net loss' (NNL) of, or 'net positive impact' (NPI) on, biodiversity (Rainey *et al.* 2014). The Business and Biodiversity Offsets Programme describes these terms as follows: 'no net loss is a target for a development project in which the impacts on biodiversity caused by the project are balanced or outweighed by measures taken to avoid and minimise the project's impacts, to undertake on-site rehabilitation/restoration, and finally to offset the residual impacts, so that no overall biodiversity loss results; where the gain exceeds the loss, the term 'net gain' (or 'net positive impact') may be used instead of no net loss'(Forest Trends 2016). A recent review of corporate goals over the period 2001 to 2014 (Rainey *et al.* 2014), identified 32 companies with NNL or NPI goals, 18 of which, specifically included biodiversity. Additionally, a number of countries have specific guidance or policies for governing NNL. However, analysis shows that the French guidance, in spite of its laudable ambition, does not address the institutional arrangements and scientific evidence needed to reach the policy's objective of NNL (Quétier *et al.* 2014). A review of offset programmes also found that biodiversity offset schemes have been inconsistent in meeting conservation objectives due to the challenge of ensuring full compliance and effective monitoring, and because of conceptual flaws in the approach itself (Bull *et al.* 2013). Consequently, and in spite of the increasing demand for offsets, the result is a highly variable, and often ineffective, project-by-project approach to offset supply, with minimal commitments. Unless the institutional and scientific challenges are tackled, the likely outcome will be an expansion of 'paper offsets'. Overall, in order to deliver NNL, biodiversity gains must be comparable to losses, be in addition to conservation gains that may have occurred in absence of the offset, and be lasting and protected from risk of failure (Gardner *et al.* 2013).

1.13.4 Knowledge and research gaps

Further research and investigation is needed in the following areas:

Current levels of production and consumption

- Internationally consistent formats for gathering and analysing data on all areas of sustainable consumption and production (Hertwich *et al.* 2010).
- Monitoring progress towards sustainable consumption and production within, and across, countries (Hertwich *et al.* 2010).
- Cross-country and cross-sector analyses of sustainable consumption and production research, policies and actions. (Hertwich *et al.* 2010).
- Identification of economic drivers that cause consumption and production impacts (Hertwich *et al.* 2010).

Innovation and policy impacts

- The factors that determine the success of sustainable consumption and production policies and responses (Hertwich *et al.* 2010).
- Innovation that addresses transdisciplinary issues, such as how to mobilise more political support and resources for sustainability strategies; how to scale up initiatives; how to find the right language for communicating issues to the general public; and how to use the educational system, mass media and social media to support movement towards sustainability (Vergragt *et al.* 2014).
- The economic, political and social factors that facilitate, or hinder, the spread of certification (Auld *et al.* 2008).
- The broader consequences of instruments, including positive and negative unintended consequences, spill-over effects, and the longer-term and slow-moving effects that flow from the emergence of a certification innovation (Auld *et al*. 2008).
- Certification's intersection with governmental, intergovernmental and civil society initiatives to address intersectoral issues related to the impact of consumption and production on the full global balance of natural resources (Auld *et al.* 2008).

1.13.5 Overview of networks and funding

The main network for sustainable consumption and production is the 10-year Framework of Programmes on Sustainable Consumption and Production Patterns (10YFP). It is a global framework of action to enhance international cooperation to accelerate the shift towards sustainable consumption and production in both developed and developing countries. The 10YFP aims to develop, replicate and scale-up sustainable consumption and production and resource-efficiency initiatives, at national and regional levels, decoupling environmental degradation and resource use from economic growth, and increasing the net contribution of economic activities to poverty eradication and social development. The United Nations Environment Programme provides the Secretariat to the 10YFP, and interested actors – governments, private sector, civil society, researchers, UN agencies and financial institutions – from all countries can be involved in the implementation of 10YFP activities. To support the aims of the 10YFP, the Global Sustainable Consumption and Production (SCP) Clearinghouse has been created. The Global SCP Clearinghouse aims to bring together

and expand the global sustainable consumption and production community by collecting, disseminating and sharing initiatives, policies, tools, best practices, news and events, as well as encouraging cooperation and partnership opportunities in order to trigger more innovation in the implementation of sustainable consumption and production.

In addition to the 10YFP, a number of other networks and funding groups exist, such as the Global Research Forum on Sustainable Production and Consumption (GRF-SPaC) created in 2012 by, and for, the community of researchers and practitioners engaged in research on the worldwide transition to sustainable production and consumption systems.

1.14 GLOBAL GOAL 13: TAKE URGENT ACTION TO COMBAT CLIMATE CHANGE AND ITS IMPACTS

1.14.1 Summary of Global Goal

Global Goal 13 calls for urgent action to combat climate change and its impacts. Climate change presents the single biggest threat to development, and its widespread, unprecedented impacts disproportionately burden the poorest and most vulnerable. Urgent action to combat climate change and minimise its disruptions is integral to the successful implementation of the Global Goals (UNECOSOC 2016b).

The United Nations Framework Convention on Climate Change (UNFCCC) is acknowledged as the primary international, intergovernmental forum for negotiating the global response to climate change. At the 21st UNFCC Conference of the Parties in Paris, 2015, Parties to the UNFCCC reached a landmark agreement to combat climate change, and to accelerate and intensify the actions and investments needed for a sustainable, low-carbon future. The Paris Agreement has a number of key aspects including (UNFCCC 2016):

- **Long-term temperature goal** (Art. 2) – In seeking to strengthen the global response to climate change, it reaffirms the goal of limiting global temperature increase to well below 2 degrees Celsius, while pursuing efforts to limit the increase to 1.5 degrees Celsius.
- **Global peaking** (Art. 4) – To achieve the long-term temperature goal, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible.
- **Mitigation** (Art. 4) – It establishes binding commitments by all Parties to prepare, communicate and maintain a nationally determined contribution (NDC), and to pursue domestic measures to achieve it.
- **Sinks and reservoirs** (Art.5) – It encourages Parties to conserve and enhance, as appropriate, sinks and reservoirs of greenhouse gases, including forests.
- **Market and non-markets** (Art. 6) – It establishes a mechanism to contribute to the mitigation of greenhouse gas emissions and support sustainable development, as well as defining a framework for non-market approaches to sustainable development.
- **Adaptation** (Art. 7) – It establishes a global goal to significantly strengthen national adaptation efforts (enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change) through support and international cooperation.
- **Loss and damage** (Art. 8) – It significantly enhances the Warsaw International Mechanism on Loss and Damage, which will develop approaches to help vulnerable countries cope with the adverse effects of climate change.
- **Support** (Art. 9, 10 and 11) – It reaffirms the obligations of developed countries to support the efforts of developing-country Parties to build clean, climate-resilient futures, while, for the first time, encouraging voluntary contributions by other Parties.

Although the UNFCCC is the primary forum for climate change, a number of other multilateral agreements have some interconnections to climate change. For example, due to the role of ecosystems and biodiversity in climate change vulnerability, adaptation and mitigation, there is a link to the Convention on Biological Diversity (CBD) and Aichi Biodiversity Target 15, which focuses on increasing the role of ecosystems in climate change mitigation and adaptation (CBD 2010b). Likewise, since many ozone-depleting industrial gases are also greenhouse gases (such as hydrofluorocarbons [HFCs]), there is a link to the ozone regime under the 1985 Vienna Convention and Montreal Protocol (UNEP 2016g).

1.14.2 Overview of main environment-human interactions

The climate is a major part of the physical environment in which humans exist. It is a major driver of agricultural production (Global Goals 1 and 2), water cycles (Global Goal 6) and terrestrial and marine ecosystem dynamics (Global Goals 14 and 15), and it can cause climatic hazards, thus impacting on poverty, health, economies, infrastructure and development more broadly (Global Goals 1, 3, 8, 9, 10 and 11). In turn, energy use (Global Goal 7), economic development (Global Goal 8), industry and infrastructure (Global Goal 9), cities (Global Goal 11), and

sustainable consumption (Global Goal 12) all affect future climate change, impacting on both the physical environment of the planet, and how resilient we are to potential changes. Indeed, in 2005, the Millennium Ecosystem Assessment (MA) showed that there was already "wide recognition that human-induced climate change is a serious environmental and development issue" (MA 2005).

The biotic environment also has a large effect on climate change and its impacts on humans – "ecosystems, both natural and managed, exert a strong influence on climate" (MA 2005). For example, land use change and deforestation are both sources of greenhouse gases. Therefore, ecosystem management can help to reduce the extent of climate change (climate change mitigation) and the impact of occurring climate change on humans (climate change adaption).

1.14.3 Synthesis of developments in research, innovations and policies

The Intergovernmental Panel on Climate Change (IPCC) provides rigorous and balanced information to decision-makers because of its scientific and intergovernmental nature. Participation in the IPCC is open to all member countries of the World Meteorological Organisation and UN; it currently has 195 members. Assessments produced by the IPCC are written by hundreds of leading scientists who volunteer their time and expertise, and enlist complementary expertise in specific areas. These reports undergo multiple rounds of drafting and review to ensure that they are comprehensive and objective, and produced in an open and transparent way. Thousands of experts contribute to the reports by acting as reviewers, ensuring they reflect the full range of views in the scientific community. A thorough monitoring mechanism is provided to make sure that review comments are addressed. The IPCC's 5th assessment report provides a comprehensive review of the state of research on climate change up to 2014; the main findings presented within the synthesis report include (IPCC 2014c):

Observed changes and their causes

- "Changes in many extreme weather and climate events have been observed since about 1950. Some of these changes have been linked to human influences, including a decrease in cold temperature extremes, an increase in warm temperature extremes, an increase in extreme high sea levels and an increase in the number of heavy precipitation events in a number of regions."
- "In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans. Impacts are due to observed climate change, irrespective of its cause, indicating the sensitivity of natural and human systems to changing climate."
- "Evidence of observed climate change impacts is strongest and most comprehensive for natural systems. In many regions, changing precipitation or melting snow and ice are altering hydrological systems, affecting water resources in terms of quantity and quality (medium confidence) [Global Goal 6]. Many terrestrial, freshwater and marine species have shifted their geographic ranges, seasonal activities, migration patterns, abundances and species interactions in response to ongoing climate change (high confidence) [Global Goals 14, and15]. Some impacts on human systems have also been attributed to climate change … Assessment of many studies covering a wide range of regions and crops shows that negative impacts of climate change on crop yields have been more common than positive impacts (high confidence) [Global Goal 2]. Some impacts of ocean acidification on marine organisms have been attributed to human influence (medium confidence) [Global Goal 14]."

Future climate changes, risks and impacts

- "Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions [Global Goal 7], which, together with adaptation, can limit climate change risks."
- "Cumulative emissions of carbon dioxide largely determine global mean surface warming by the late 21st century and beyond. Projections of greenhouse gas emissions vary over a wide range, depending on both socioeconomic development and climate policy [Global Goals 7, 8 and 12]."
- "Surface temperature is projected to rise over the 21st century under all assessed emission scenarios. It is very likely that heatwaves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions. The ocean will continue to warm and acidify, and global mean sea level to rise."
- "Climate change will amplify existing risks and create new risks for natural and human systems. Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development [Global Goals 1 and 10]."

- "Many aspects of climate change and associated impacts will continue for centuries, even if anthropogenic emissions of greenhouse gases are stopped. The risks of abrupt or irreversible changes increase as the magnitude of the warming increases."

Future pathways for adaptation, mitigation and sustainable development

- "Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. Substantial emissions reductions over the next few decades can reduce climate risks in the 21st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term, and contribute to climate-resilient pathways for sustainable development."
- "Effective decision-making to limit climate change and its effects can be informed by a wide range of analytical approaches for evaluating expected risks and benefits, recognising the importance of governance, ethical dimensions, equity, value judgments, economic assessments and diverse perceptions, and responses, to risk and uncertainty."
- "Without additional mitigation efforts beyond those in place today, and even with adaptation, warming by the end of the 21st century will lead to high to very high risk of severe, widespread and irreversible impacts globally (high confidence). Mitigation involves some level of co-benefits and of risks due to adverse side effects, but these risks do not involve the same possibility of severe, widespread and irreversible impacts as risks from climate change."
- "Adaptation can reduce the risks of climate change impacts, but there are limits to its effectiveness, especially with greater magnitudes and rates of climate change. Taking a longer term perspective, in the context of sustainable development, increases the likelihood that more immediate adaptation actions will also enhance future options and preparedness."
- "There are multiple mitigation pathways that are likely to limit warming to below 2 degrees Celsius relative to pre-industrial levels. These pathways would require substantial emissions reductions over the next few decades, and near zero emissions of carbon dioxide and other long-lived greenhouse gases by the end of the century. Implementing such reductions poses substantial technological, economic, social and institutional challenges, which increase with delays in additional mitigation and if key technologies are not available. Limiting warming to lower or higher levels involves similar challenges, but on different timescales."

Adaptation and mitigation

- "Many adaptation and mitigation options can help address climate change, but no single option is sufficient by itself. Effective implementation depends on policies and cooperation at all scales and can be enhanced through integrated responses that link adaptation and mitigation with other societal objectives."
- "Adaptation and mitigation responses are underpinned by common enabling factors. These include effective institutions and governance, innovation and investments in environmentally sound technologies and infrastructure [Global Goal 9], sustainable livelihoods and behavioural and lifestyle choices."
- "Adaptation options exist in all sectors, but their context for implementation and potential to reduce climate-related risks differs across sectors and regions. Some adaptation responses involve significant co-benefits, synergies and trade-offs. Increasing climate change will increase challenges for many adaptation options."
- "Mitigation options are available in every major sector [Global Goals 2, 8 and 12]. Mitigation can be more cost-effective if using an integrated approach that combines measures to reduce energy use and the greenhouse gas intensity of end-use sectors [Global Goal 7], decarbonise energy supply, reduce net emissions and enhance carbon sinks in land-based sectors [Global Goals 2 and 15]."
- "Climate change is a threat to sustainable development. Nonetheless, there are many opportunities to link mitigation, adaptation and the pursuit of other societal objectives through integrated responses (high confidence). Successful implementation relies on relevant tools, suitable governance structures and enhanced capacity to respond (medium confidence)."

In addition to the main state of current research on climate change, as summarised by the IPCC report findings listed here, there have also been a number of innovation and policy developments in recent years that are not fully captured by the IPCC reports main findings. These include:

- International agreements (Paris, Nationally Determined Contributions) and local polices and commitments (noting that the recent United Nations Environment Programme Emissions Gap Report highlighted that current commitments only bring us part of the way to

limiting warming to 2 degrees Celsius (UNEP 2015a)).
- Actions on Reducing Emissions from Deforestation and forest Degradation plus conservation of forest carbon stocks, sustainable management of forests and enhancement of forest carbon stocks (REDD+) (Global Goal 15).
- Increasing emphasis on non-state actors and initiatives, as well as state actors (Bulkeley *et al.* 2014).
- Climate smart agriculture (Global Goal 2).
- Use of ecosystems in reducing climate risks to humans; ecosystem based adaptation (EBA; Global Goals 1, 2, 6, 14 and 15).
- Technological advances in renewables, and carbon capture and storage (CCS).
- Increasing discussion of negative emissions and bioenergy carbon capture and storage (BECCS).

1.14.4 Knowledge and research gaps

The IPCC 5th assessment reports present the main research and knowledge gaps for each of the chapters. The full list of knowledge gaps listed in the IPCC report amounts to nearly 50 pages. However, the main issues that emerge include (IPCC 2013; IPCC 2014a; IPCC 2014b):

Understanding climate change impacts

- Understanding of recent and future changes in the climate in terms of global precipitation, cloud variability, drought, cyclone characteristics, large-scale atmospheric circulation, sub-surface ocean temperatures, ocean circulation features and ice-ocean interactions.
- Projections of the physical impacts of climate change (especially rainfall, drought, sea-level rise) at spatial and temporal scales needed by decision-makes including in small island developing states (SIDS). As well as projections that tackle the uncertainty inherent in forecasting, including those that cover a range of outcomes, explain the differences in different projections and tackle extreme events, as well as gradual changes in the mean.
- Knowledge of the impacts of climate change within complex systems, including second and third order impacts, and the interdependence between systems (for example, between climate and non-climate change drivers, socioeconomic and natural systems). This may be achieved by improving integrated assessment models and assessing impacts on development and economic growth.
- Research into the impacts of climate change on health due to vector-borne diseases, changes in water quality and climate variability, and impact of climate change on industry
- Feedbacks, tipping points and thresholds also need to be investigated; for example, the quantification of cloud feedback; the impacts of carbon dioxide and nitrogen deposits on plants and so on sinks and emissions; socioeconomic feedbacks in polar regions; and thresholds for impacts due to the combined effects of temperature and precipitation.

Potential mitigation and adaptation responses

- New socioeconomic and technology storylines and scenarios that include impacts from, and adaptation to, climate change, and land-use based mitigation options are also required (note that new scenarios are being developed for the next IPCC assessment report).
- Assessments, especially economic assessments, of the potential impacts (costs and benefits), of a broad range of adaption and mitigation measures (including both soft and transformative measures), and the impacts of potential loss of biodiversity and ecosystems. This is especially true for sectors such as business, biodiversity and population health, as well as assessments that include microeconomic decision-making, behavioural economics, and potential for reducing emissions from material efficiency and demand-side options.
- Reviews of the impacts, costs, and environmental side effects of CCS and BECCS, and unconventional fossil fuels, as well as, on geoengineering costs, benefits, risk, and ethics.

Effectiveness of mitigation and adaptation response

- Investigations into the effectiveness of different types of current and future mitigation and adaptation policies and regulations (both singly and jointly, including net impacts). Monitoring and evaluation of mitigation and adaptation measures is needed. Additionally, reviews need to cover: comparisons of which underlying drivers different policies are addressing; understanding of methodologies used in past studies with different findings on connections between greenhouse gas emissions and specific policies and measures; assessments of current frameworks for compensation of foregone emissions; non-economic motivations for climate-friendly behaviours; distributional impacts of climate policies; and net effect of trade.
- Reviewing the unintended consequences, trade-offs and synergies (in economic, social and environmental direct and indirect impacts) between climate change policies and development, and between climate change mitigation and adaptation policies is essential; for example, the potential trade-offs between

biofuels, food and livelihood security, and the potential impacts of REDD+.

- Research is needed into the role of governance and institutions in addressing climate change, which institutional arrangements are most effective at which level enabling environments for climate finance, and the transition to sustainable strategies for institutional development (including research on approaches to improving co-ordination between different levels in society and agencies).
- It is also important to build on, and link to, local indigenous knowledge.

1.14.5 Overview of networks and funding

There are an increasingly large number of climate change-related networks. The most central for coordination and synthesis of new knowledge on climate change is the IPCC. There are also a large number of more specific, topic-focused networks, such as the UN Alliance on Climate Change Education, Training and Public Awareness, the Global Cites Network (ICLEI), and PROVIA – an adaptation network. Networks range from those officially established through the UNFCCC, to more informal communities of practise (such as weAdapt), networks of non-governmental organisations (NGOs; such as the Climate Action Network), and networks which bring together public, private and NGOs (such as the Climate and Development Knowledge Network).

In terms of funding, Global Environment Facility was entrusted in 2006 as one of the operating entities of the Financial Mechanism of the UNFCCC, as well as the Least Developed Countries Fund and the Special Climate Change Fund. In 2015, the Green Climate Fund was established at the UNFCCC Conference of the Parties 16 as an operating entity of the Financial Mechanism of the Convention. Additionally, there are a number of World Bank administered funds (such as the Climate Investment Funds), and national funding initiatives, such as Germany's International Climate Initiative and Norway's International Climate and Forest Initiative.

1.15 GLOBAL GOAL 14: CONSERVE AND SUSTAINABLY USE THE OCEANS, SEAS AND MARINE RESOURCES FOR SUSTAINABLE DEVELOPMENT

1.15.1 Summary of Global Goal

Oceans, seas and marine resources play an essential role in human well-being and social and economic development worldwide (UNECOSOC 2016b). Global Goal 14 recognises this and calls for the conservation and sustainable use of the oceans, seas and marine resources for sustainable development. It covers issues of marine pollution, acidification, conservation and protection, sustainable management, and resilience.

The overarching framework for ocean governance is set by the United Nations Convention on the Law of the Sea (UNCLOS), which provides rights and duties to coastal states. The specific issues within Global Goal 14 are addressed by different regional and global agreements. For example, marine pollution is covered by the 1972 MARPOL and the London Convention, and sustainable fisheries is addressed by the 1995 UN Fish Stocks Agreement related to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stock.

1.15.2 Overview of main environment-human interactions

Global Goal 14 is fundamentally about human interactions with a part of the environment – the oceans. Oceans cover nearly three-quarters of the planet's surface. Billions of people are directly dependent on them for food, protein and nutrients (Global Goal 2, Global Goal 12), and they are crucial for regulating our climate system (Global Goal 13).

The Millennium Ecosystem Assessment (MA) (2005) noted that coastal ecosystems are among the most productive systems in the world, producing more benefits to human well-being than most others. Yet they are highly threatened. For instance, the MA showed that, in 2005, coastal fisheries in all regions of the world had depleted stocks of finfish, crustaceans, and molluscs (MA 2005). Similarly, high rates of loss of coastal ecosystems were reported, with many coastal areas being degraded or altered, resulting in humans facing increasing coastal erosion and flooding, declining water quality, and increasing health risks (MA 2005). The MA (2005) also noted that, in order to halt the degradation of coastal and marine systems, a cross-sectoral, integrated policy response is required. Approaches proposed as possible actions included integrated coastal management, marine protected areas with no-take zones, and comprehensive ocean zoning.

1.15.3 Synthesis of developments in research, innovations and policies

Protection of marine and coastal ecosystems

The First Global Integrated Marine Assessment (Inniss *et al.* 2016) highlights the broad range of services to society that the oceans provide – from generating half the oxygen we breathe, to supplying food to eat, from creating highways for

ships, to providing routes for submarine cables that carry 90 per cent of our electronic traffic. But the oceans, along with the marine biodiversity they support, are under pressure from ever-increasing demands, including those resulting from climate change (Global Goal 13) and the increased use of marine biodiversity hotspots for economic and social benefits. Managing how the oceans are used is, therefore, vital to the continued well-being of humans and the planet (Inniss *et al.* 2016). Additionally, increasing their resilience to adverse impacts is essential to improved management**.** There are several widely used methods for the protection of coastal and marine ecosystems, including marine protected areas (MPAs), restoration schemes, and regulations on activities and uses. The number and extent of MPAs has expanded considerably during the past century. There are 14,688 MPAs recorded in the World Database on Protected Areas (WDPA). These cover 4.12 per cent (14.9 million km^2) of the global ocean and 10.2 per cent of coastal and marine areas under national jurisdiction (UNEP-WCMC *et al.* 2016). However, MPA coverage in itself tells us little about the effectiveness of conservation outcomes, nor how they alter on the ground activities. Only approximately one-sixth of the combined areas of MPAs is designated as 'no-take' in which extractive activities are prohibited (Boonzaier *et al.* 2016).

A significant majority of MPAs are affected by pollution from cumulative shipping traffic, ocean-based pollution sources, organic and inorganic pollution sources, artisanal fishing, and invasive species (Partelow *et al.* 2015). Pollution originates from both terrestrial and marine sources, suggesting a need to integrate MPA management into broader terrestrial and marine conservation and management approaches.

Restoration of marine and coastal ecosystems

Many marine species and ecosystems have experienced historical depletions, yet, in 2011, Lotze et al. found that 10 to 50 per cent of depleted marine populations and ecosystems showed some recovery. However, few have recovered to former abundance levels. This shows that recovery of depleted marine species and ecosystems is possible, but the magnitude of recoveries so far is insufficient to halt the overall decline. Studies reviewing the key factors for successful restoration (Borja *et al.* 2010; Lotze *et al.* 2011; Verdonschot *et al.* 2013) have found that the variable, and often long, timeframes involved in restoration are an important consideration. Although recovery can take less than five years, especially for the short-lived and high-turnover biological components, full recovery of an ecosystem to its original biotic composition may take a minimum of 15 to 25 years, and much longer to achieve prior diversity levels (Borja *et al.* 2010). Other factors that enhance the effectiveness of marine restoration include (Lotze *et al.* 2011; Verdonschot *et al.* 2013):

- clearly defining restoration goals at the site scale;
- raising public and political awareness;
- taking legal action to enforce management measures (including in terms of sustainable use);
- addressing cumulative human impacts;
- maintaining or restoring biodiversity and ecosystem complexity;
- planning for the long term in order to take into account extended recovery times for some long-lived species and complex ecosystems;
- sharing and promoting the uptake of best practice restoration measures; and
- using effective monitoring designed to address the goals of restoration.

Sustainable use of coastal ecosystems – fisheries

Fisheries and aquaculture are two of the main uses of the oceans today. As highlighted by the World Oceans Assessment (Inniss *et al.* 2016), fish products are a major source of protein for a significant fraction of the world's population, particularly in countries where hunger is widespread (Global Goal 2). Inshore marine ecosystems are especially important to Small Island Developing States (SIDS) (UNEP/UNCTAD 2014), with fisheries representing a significant part of their economic output (UNCTAD *et al.* 2014). Globally, small-scale fisheries, particularly subsistence fisheries in poor communities, are often particularly important to food security and employment (Inniss *et al.* 2016). In 2014, about 85 per cent of the world's motorised fishing vessels were less than 12m in length and dominated fishing fleets in all regions (FAO 2016b). Small-scale fisheries employ the majority of the world's fishers, provide food and livelihoods to a vast number of people living in coastal areas, support poverty alleviation (Global Goal 1) and food security (Global Goal 2), and encourage pro-poor growth (Béné 2006; Chuenpagdee *et al.* 2006). Nevertheless, they are unlikely to have a macroeconomic impact in most countries, and their global economic contribution is difficult to assess, despite their critical role in supporting local-scale economic activity (Béné 2006).

The productivity of many fish stocks has been carefully studied, and found to vary spatially. For example, the Northwest Pacific remains the most productive area for capture fisheries, whereas productivity in both the Mediterranean and Black Sea has declined by one-third since 2007 (FAO 2016b). Information about small-scale fisheries is

scarce and scattered, however, often because it is difficult to obtain due to their large number, and the remoteness of their activities and landing sites (Chuenpagdee *et al.* 2006).

The World Ocean Assessment (Inniss *et al.* 2016) shows that the exploitation of living marine resources has exceeded sustainable levels in many regions. According to the State of Fisheries report (FAO 2016b), the overall condition of the world's marine fish stocks has not improved, despite notable progress in some areas. A total of 31 per cent of global fish stocks were estimated as being fished at a biologically unsustainable, or overfished, level (FAO 2016b). This may even be an underestimate as other studies have suggested catch trajectories that differ considerably from the data submitted to the FAO (Pauly *et al.* 2016). As well as the direct effects of overfishing, there are several indirect effects of fishing on marine ecosystems and their productivity, including: by-catch (unwanted trapping of marine creatures during fishing for a different species); impacts on seabirds; impacts on marine reptiles; and habitat modifications (Inniss *et al.* 2016). The sustainability of fisheries also needs to be considered in relation to the threats of climate change and noise pollution, and the impacts of recreational fishing.

The current state and future prospects of global fisheries vary globally. Well-assessed, wealthy regions, with improved controls on exploitation rates, show a stabilisation of fish biomass; whereas other regions show continuing decline due to low management capacity (Worm *et al.* 2012). Measures already exist to reduce the negative impacts of fisheries, including using acoustic deterrents and fishing gear modifications to reduce by-catch, and enforcing seasonal or area-based closures to reduce fisheries effort (Inniss *et al.* 2016). More effective implementation of codes and guidelines, such as the FAO Code of Conduct for Responsible Fisheries, could also help to address overfishing and build ecosystem resilience to climate change (UNEP/UNCTAD). In terms of innovation in sustainable fisheries, the number of voluntary certification schemes that promote sustainable resource management and reward responsibly sourced seafood products has increased since 2000, with improved uptake by major import markets (FAO 2016b). Overall, the control of fishing operations within Exclusive Economic Zones (EEZs) is now much stronger, but there is less control in Areas Beyond National Jurisdiction (ABNJ) (FAO 2016b). On the other hand, it is also estimated that capacity-enhancing subsidies, which can incentivise overfishing, form the biggest category of total fisheries subsidies (Sumaila *et al.* 2016).

In general, overexploitation makes fish stocks less productive, so ending overfishing (including illegal, unreported and unregulated fishing) and rebuilding depleted resources could result in a predicted increase of as much as 20 per cent in catches (Inniss *et al.* 2016). To achieve this the social and economic costs of rebuilding depleted stocks would need to be addressed (Inniss *et al.* 2016). National development policies should include the social, cultural, economic and livelihood importance of small-scale fisheries, rather than just emphasising large-scale, industrial fisheries (Chuenpagdee *et al.* 2006).

Sustainable use of coastal ecosystems – aquaculture

The contribution of aquaculture to food security is growing. Aquaculture production, including seaweed culture, is increasing more rapidly than any other source of food production in the world, and growth is expected to continue (Inniss *et al.* 2016). Indeed, aquaculture has greater potential for growth than capture fisheries (Inniss *et al.* 2016) and is mainly responsible for the 3.2 per cent annual increase in the supply of fish for human consumption between 1961 and 2013 (FAO 2016b). Aquaculture, not including seaweeds, now provides half of fish products (Inniss *et al.* 2016). Aquatic plant farming (predominately seaweeds) has been growing at 8 per cent per year over the past decade and is now practised in approximately 50 countries (FAO 2016b).

Aquaculture and capture fisheries are co-dependent in many instances because feed for culture fish is, in part, provided by capture fish. Aquaculture poses some environmental challenges, including pollution, contamination of gene pools, disease and, in some cases, loss of habitat (Inniss *et al.* 2016). Nonetheless, about half of the world's aquaculture production comes from non-fed species (e.g. silver carp, bivalve molluscs and seaweeds), potentially increasing their sustainability and role in food security, while limiting their environmental impact (FAO 2016b).

Sustainable use of the oceans – a blue-green economy

A green economy "improves human well-being and social equity, while significantly reducing environmental risks and ecological scarcities". A blue-green economy takes into account the marine and coastal environment, and encourages key sectors that are interlinked with the 'blue world' to make the transition towards a green economy (UNEP *et al.* 2012). It offers many potential benefits, especially in SIDS (UNEP/UNCTAD). Many sectors are dependent on ocean space including: fishing, fisheries management and aquaculture; coastal development and

urbanisation; tourism and recreation; shipping; offshore hydrocarbon industries; submarine cable and pipeline industries; seafloor mining; marine renewable energies; and MPAs (Inniss *et al.* 2016). Increased use of ocean space from both long-standing uses (such as fishing) and newly developed uses (such as mining the seabed for rare minerals), makes generating a sustainable mix of uses a challenge (Inniss *et al.* 2016). Each of the different sectors that use the ocean have a variety of impacts; for example, the impact of coastal tourism comes from: the construction of coastal resorts and roads; pollution; access to remote locations by large cruise ships; disturbance caused by intertidal trampling by tourists on rocky and sandy shores; effects of beach cleaning; and the effects of sailing, SCUBA diving and motorboats (Davenport *et al.* 2006). Tourism and the environment are also discussed in Global Goal 8.

The long list of marine uses shows that there are simply too many demands for all to be accommodated in a way that will not constrain some aspect of their operation (Inniss *et al.* 2016). When the many pressures on the oceans are considered cumulatively, they generate complex threats to marine biodiversity (Inniss *et al.* 2016). Therefore, the sustainable use and conservation of the oceans cannot be achieved without the coherent management of all sectors of human activities affecting the oceans (Inniss *et al.* 2016).

Marine pollution

One of the main themes of the World Oceans Assessment (Inniss *et al.* 2016) is the growing levels of industrial and agricultural production resulting in increasing inputs of harmful chemicals and nutrients into the ocean . The reports considers issues such as: land-based, heavy metals and other hazardous substances from industrial process (e.g. lead, mercury, copper and zinc); land-based oil pollution; nutrients and pesticides from agricultural activities; eutrophication from excess nutrients from agriculture and sewage which cause harmful algal blooms; radioactive substances; solid waste disposal; marine debris; shipping; offshore hydrocarbon industries; and offshore mining (Inniss *et al.* 2016).

The main drivers of pollution identified by the report include:

- the growing concentrations of human populations, which generate levels of sewage discharge that exceed the local carrying capacity and risk harm to human health;
- the likelihood of continued growth in production increasing pollution even if discharges of industrial effluents and emissions are restrained to the lowest levels currently practical; and
- the growing use of slow-degrading plastic, thus generating increased concentrations of plastic in the oceans (Inniss *et al.* 2016).

A review of pollution sources in the open ocean (GESAMP 2015) assessed the degree of human input and the impact of specific pollutants. The report identifies atmospheric inputs of carbon dioxide (discussed in the oceans acidification section), inputs of nitrogen, deep-water mining and exploration, and marine debris as matters of special concern because of their potential to damage marine organisms and ecosystems well beyond the local pollution source. Other pollutants identified as being of concern include mercury, noise and Persistent Organic Pollutants (POPs). The Group of Experts on the Scientific Aspect of Marine Environmental Protection (GESAMP 2015) also stresses the impact of macroscale debris, and highlights the unclear impact of the nanoparticles it decomposes into. It showcases initiatives, such as the Global Partnership on Marine Litter, which have been set up to address these issues. The review did not assess all the literature on deep-water extraction of seabed resources, but noted that the potential for environmental damage by such activities is sufficiently great enough that the matter should be addressed by the international community (GESAMP 2015). The fact that living components of the marine environment are subject to multiple stressors, many at low levels but acting in consort, is recognised throughout the report.

Pollution and discharge can compromise food safety (Global Goal 2), especially due to contamination of food from pathogens (from discharges of untreated sewage and animal waste) and toxins (often from algal blooms). International guidelines to address these risks exist, but substantial resources are required to build capacity to implement and monitor safety protocols from the water to the consumer (Inniss *et al.* 2016).

Ocean acidification

Ocean acidification is one of the major issues identified by the World Oceans Assessment (Inniss *et al.* 2016) and GESAMP (2015). The surface of the ocean currently absorbs approximately one-third of the excess carbon dioxide injected into the atmosphere by humans; this leads to an increase in acidity and a wholesale shift in seawater carbonate chemistry (Doney *et al.* 2009). This chemical shift represents a threat to marine species worldwide, so forecasting the ecological impacts of acidification is a high priority for scientists, managers and policymakers (Kroeker *et al.* 2013).

There is an expanding body of research on the impacts of acidification on species (Doney *et al.* 2009; Kroeker *et al.* 2013; Hilmi *et al.* 2015).

Looking across the broad range of marine organisms, impacts from acidification include decreased survival, calcification, growth, development and abundance (Kroeker *et al.* 2013). Numerous species have been studied and negative impacts predominate for diverse phyla, including echinoderms, corals, molluscs, and calcifying plankton but a large diversity of tolerance is apparent both across and or within species (Hilmi *et al.* 2015). Biologically, organisms with calcium carbonate structures, such as corals and bivalves, are particularly sensitive to acidification (GESAMP 2015). Despite regional similarities, ocean acidification does not occur uniformly. Instead 'hotspots' of acidification are found, most likely due to large-scale ocean processes. Hotspots include the Arctic and Southern Oceans, and coastal upwelling zones (Hilmi *et al.* 2015). Overall the change in conditions of the chemical state of ocean waters will have biological effects at the species level, which may translate to ecosystem shifts of unknown proportions and directions (GESAMP 2015; Hilmi *et al.* 2015). Indeed, most evidence points to negative consequences from ocean acidification for human communities and associated human activities reliant upon marine resources. The synergistic combination of ocean acidification with other pressures is likely to generate additional negative consequences (Kroeker *et al.* 2013; Hilmi *et al.* 2015).

Addressing and managing life under the water

The conservation and sustainable use of the oceans are, first and foremost, a political task (Inniss *et al.* 2016). At the highest political level, several different UN institutions are dealing concurrently with different aspects of the ocean; for instance, the International Maritime Organization (IMO) lays down the rules for international commercial shipping, and the International Seabed Authority (ISA) administers the mineral resources located in high seas areas. At a regional scale, despite almost 600 regional agreements existing which regulate particular uses in a delimited region, there are very few positive examples of really effective ocean governance (van Doorn *et al.* 2015). While single-sector measures have the potential to make a valuable contribution, ultimately only multi-sectoral, integrated, cooperative management can ensure the conservation and long-term sustainable use of marine biodiversity in areas beyond national jurisdiction (Ardron *et al.* 2014), and in areas inside national jurisdictions.

1.15.4 Knowledge and research gaps

The World Oceans Assessment (Inniss *et al.* 2016) notes that the "greatest threat to the oceans comes from a failure to deal quickly with the manifold problems". It has been suggested that we already know what we need to change, so now the main knowledge gap is how to get actionable policies (Daniel Pauly, pers. comm., 2016). However, the World Oceans Assessment also notes that "we do not have the detailed knowledge desirable for effective future management of human use of the ocean" (Inniss *et al.* 2016). Overall, the main knowledge gaps are:

Protection, restoration and management

- Local information for use in coastal zone management (e.g. local economic activities, coastal erosion and changes in sedimentation) and knowledge on how to manage the coastal zone in an integrated way (Inniss *et al.* 2016).
- Ways we benefit from the oceans, especially in terms of valuing non-marketed ecosystem services (Inniss *et al.* 2016).
- The most important factors for restoration and recovery, and their interactions, including assessing cause-effect relationships and management measures through long-term monitoring and understanding ecological responses (Verdonschot et al. 2013).
- The ability of marine protected areas to buffer the impacts of anthropogenic pollution at a global scale (Thomas *et al.* 2014).
- Particular species or ecosystems that are threatened, declining or otherwise in need of special attention or protection (e.g. cold water corals, high-latitude ice, migration routes of seabirds) (Inniss *et al.* 2016).
- Where and when ship-routing measures needed to protect the marine environment (Inniss *et al.* 2016).

Fisheries

- Fish stock assessments, especially for small-scale fisheries which are currently under assessed (Chuenpagdee *et al.* 2006; Inniss *et al.* 2016), and the health and reproductive success of separate populations of marine species, particularly in the southern hemisphere (Inniss *et al.* 2016).
- Interactions between large-scale and small-scale fisheries, and between recreational fishing and other fisheries for some species (Inniss *et al.* 2016).
- Impact of fisheries subsidies and the need for them (Sumaila *et al.* 2016).

Other uses of the oceans

- How offshore hydrocarbon industries are affecting the local marine environment in some parts of the world, and the impacts of the expansion of offshore mining (GESAMP 2015; Inniss *et al.* 2016).
- How shipping routes and operations affect the marine environment, including due to the noise they make, chronic discharges of oil and the transportation of non-native species (Inniss *et*

al. 2016). Particular attention must be paid to the cumulative, long-term effects of noise and the synergy between noise and other anthropogenic pressures (GESAMP 2015).

Waste and pollution

- Sampling, analysing and interpreting land-based inputs to the ocean, including in terms of how to link different ways of measuring discharges, and to compare across studies. (Inniss *et al.* 2016). The origin and spatial distribution of land-based pollution (Partelow *et al.* 2015).
- Disposal of solid waste at sea (Inniss *et al.* 2016).
- Marine debris in terms of sources, fates and impacts on coastal and marine species, habitats, economic well-being, human health and safety, and social values; in particular, origin, fate and effects of plastic microparticles and nanoparticles (Inniss *et al.* 2016).
- Extent to which people are suffering from diseases that are either the direct result of inputs of waterborne pathogens or toxic substances, or the indirect result of toxins from algal blooms, and the economic implications of such diseases (Inniss *et al.* 2016).
- The net effect of multiple stressors on individual groups of organisms (GESAMP 2015).

Acidification

- Causes and implications of variations in the level and impacts of acidification (Inniss *et al.* 2016), including responses of whole ecosystems, the impacts of multiple stressors, and the potential for evolutionary adaptation, as well as the impacts on biogeochemical cycles, fish and fisheries and the size of the socio-economic impacts (Hilmi *et al.* 2015).

Ocean characteristics

- Understanding sea temperature (at the surface and at depth), sea-level rise, salinity distribution, carbon dioxide absorption, nutrient distribution and cycling (Inniss *et al.* 2016). Many of these are linked to research needed to understand climate change (Global Goal 13), so coordination is needed.
- Mapping of the physical structure of the oceans in some regions and extending continuous plankton recorder surveys to obtain comprehensive global coverage (Inniss *et al.* 2016).

1.15.5 Overview of networks and funding

Ocean-related networks range from groups of scientists operating through research collaborations (such as the Nereus partnership led by the University of British Columbia), to regional governance bodies (such as Regional Fisheries Management Organisations) and official UN mechanisms for collaborating and coordinating assessments (such as GESAMP). Many of the networks are topic-specific, with a number of networks related to fisheries (e.g. The Fisheries Transparency Initiative and The Global Sustainable Seafood Initiative), pollution (e.g. Global Partnership on Marine Litter), acidification (e.g. Ocean Acidification Network) or ocean observation (e.g. International Ocean Data in Information Exchange and The Global Ocean Observing System). Additionally, there is a relatively recently established regular process for global reporting and assessment of the state of the marine environment, including socioeconomic aspects, which produced the first Global Oceans Assessment in 2016. The process was established by the UN General Assembly to provide a global mechanism for reviewing the state of the marine environment.

The main funding sources for oceans research include foundations like the Calouste Gulbenkian Foundation, David and Lucille Packard Foundation and Fondazione Bertarelli.

1.16 GLOBAL GOAL 15: PROTECT, RESTORE AND PROMOTE SUSTAINABLE USE OF TERRESTRIAL ECOSYSTEMS, SUSTAINABLY MANAGE FORESTS, COMBAT DESERTIFICATION, AND HALT AND REVERSE LAND DEGRADATION AND HALT BIODIVERSITY LOSS

1.16.1 Summary of Global Goal

Global Goal 15 aims to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. It aligns closely with the Convention on Biological Diversity (CBD) Strategic Plan for Biodiversity 2011-2020, and its Aichi Biodiversity Targets (especially Targets 5, 11, 14 and 15) (CBD 2010b), which have been recognised or supported by the governing bodies for several of the other biodiversity-related multilateral environmental agreements, including the United Nations Convention to Combat Desertification (UNCCD).

1.16.2 Overview of main environment-human interactions

Environment-human interactions are central to the achievement of Global Goal 15. Ultimately, we all depend on the Earth's ecosystems, and the services they provide, for food, water, disease management, climate regulation, spiritual fulfilment and aesthetic enjoyment (MA 2005). The Millennium Ecosystem Assessment (MA) noted that many options exist to conserve or enhance ecosystem services in ways that reduce negative trade-offs, or that provide positive synergies with other ecosystem services.

The conservation of terrestrial ecosystems is essential for ensuring the continued provision of the large number of services that ecosystems provide to humans, including those important for reducing poverty and environmental hazards (Global Goal 1), providing food (Global Goal 2), and contributing to health (Global Goal 3), water security (Global Goal 6), energy supplies (Global Goal 7), climate change mitigation and adaptation (Global Goal 13), and influencing services from the oceans (Global Goal 14). Ensuring that economic growth and consumption and production can occur without negative impacts on the environment is key to Global Goals 8 and 12.

1.16.3 Synthesis of developments in research, innovations and policies

Conservation

Due to the wide range of ways that humans interact with the environment (as outlined throughout this report), there are many ways in which the management of these interactions can help in conserving terrestrial ecosystems, support the continued supply of their services (including cultural services), and conserve biodiversity more broadly. Loss of forests, for example the Brazilian Amazon, has been slowed, however, deforestation in many other tropical areas is still increasing, and other habitats, including grasslands, wetlands and river systems, continue to be fragmented and degraded (CBD 2014). Despite unprecedented increases and spread in the global drivers of environmental change, some effective options exist for limiting ecosystem loss via conservation practices (UNEP 2012a).

Protected areas (PAs) are one of the essential specific policy responses that supports the conservation of ecosystems. They have been broadly successful in reducing habitat loss (Joppa *et al.* 2011) and have had positive impacts on a range of species, including lowering the risk of extinction for those species whose most important sites were protected (Geldmann *et al.* 2013). This importance is articulated by Aichi Biodiversity Target 11 of the CBD, where governments have committed to conserving 17 per cent of terrestrial and inland water areas globally by 2020, through 'ecologically representative' PAs; this is an increase from the currently conserved 14.7 per cent (19.8 million km^2) (UNEP-WCMC *et al.* 2016). Although PAs cover 59 to 68 per cent of all terrestrial ecoregions, species are less thoroughly protected – 57 per cent of 25,380 assessed species are inadequately covered (Butchart *et al.* 2015). Furthermore, less than 20 per cent of Key Biodiversity Areas are completely protected (UNEP-WCMC *et al.* 2016). Overall, PA networks remain ecologically unrepresentative and many critical sites for biodiversity are poorly conserved (CBD 2014). Nonetheless, some species would almost certainly be extinct without the protection afforded by PAs (Butchart *et al.* 2006; Young *et al.* 2014; Hoffmann *et al.* 2015; UNEP-WCMC *et al.* 2016). Gray et al. (2016) showed the benefit of PAs to a taxonomically broad range of species and found that species richness is 10.6 per cent higher, and abundance 14.5 per cent higher, at sites sampled inside PAs than outside them; partly due to differences in land use between protected and unprotected sites.

Degradation and restoration

Land degradation is occurring in almost all terrestrial biomes and ecosystems, and has especially severe impacts on the livelihoods of the poor (Global Goal 1), who are heavily dependent on natural resources. The Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) defines degraded land as "land in a state that results from persistent decline or loss of biodiversity and ecosystem functions and services that cannot fully recover unaided within decadal timescales. 'Land degradation', in turn, refers to the many processes that drive the decline or loss of biodiversity, ecosystem functions or services and includes the degradation of all terrestrial ecosystems" (IPBES 2015). In its broadest sense, land degradation is especially relevant to food production (Global Goal 2) and the quantity and quality of water available (Global Goal 6) due to altered hydrological processes, loss of surface soil and changes in patterns of demand. Degradation, especially of forests, is a large source of carbon dioxide emissions (Global Goal 13); in turn, climate change can exacerbate degradation processes.

Land degradation affects about 30 per cent of global land area, and about 3 billion people reside in degraded lands (Nkonya *et al.* 2016). The direct anthropogenic drivers of degradation include: deforestation and the conversion of other native vegetation; management practices on grazing land, cropland and forest land, including the alteration of fire regimes; extraction of biological and mineral resources; land abandonment; and infrastructure development (Global Goals 2, 8, 9,

and 12). The annual global cost of land degradation due to land-use change, land-cover change and land-degrading management practices in existing cropland and grazing land is estimated to be USD 300 billion; indeed, the majority of the cost of land degradation due to land-use and land-cover change is borne by the off-farm beneficiaries of ecosystem services (Nkonya *et al.* 2016).

Increasing international attention to the economic and environmental importance of degradation, and the potential benefits of restoration, has led IPBES to initiate a major assessment on the topic. The IPBES Land Degradation and Restoration Assessment (LDRA), due to be released in 2018, will synthesise current knowledge and understanding on degradation and restoration, their drivers, status and trends, and impacts, and will identify response options and future research needs (IPBES 2015).

Restoration, intentional activity that initiates or accelerates the recovery of an ecosystem from degradation (IPBES 2015), is becoming increasingly important in a number of contexts. For instance, many countries have made large commitments to restoration, especially of forest, as a contribution to climate change mitigation (Global Goal 13), and to land degradation neutrality under the UNCCD.

There is considerable research and discussion on conceptual issues around objectives and definitions, as well as techniques, technical approaches and enabling factors, for effective restoration in systems ranging from lakes to dry rangelands and tropical forests. These issues and findings are largely context-dependent; for example, (Sondergaard *et al.* 2007; Chazdon 2008; FAO 2015; Locatelli *et al.* 2015; Chazdon *et al.* in press). There has been increasing emphasis on landscape-scale approaches and multi-criteria based decision-making to deliver multiple objectives for both people and nature (IUCN *et al.* 2014; Laestadius *et al.* 2015; Latawiec *et al.* 2015). Research has highlighted the importance of the enabling environment, including appropriate design of economic and policy incentives (Nkonya *et al.* 2016). The potential of community-based and participatory approaches in some systems, and the importance of indigenous and local knowledge in setting restoration objectives, have also been stressed. Scientific understanding of how recovery occurs through restoration, and how to assess it, is variable. Ecological restoration has been found to enhance biodiversity and ecosystem service provision, but not to the same levels as present in unperturbed systems (Rey Benayas *et al.* 2009); plus, recovery rates differ among ecosystem services and among ecosystems.

Sustainable use

The use of biodiversity and ecosystems supports many livelihoods (Global Goal 1), and includes the use of wild species and land for food production (Global Goal 2), medicines (Global Goal 3), and wetland and watersheds for water supply (Global Goal 6). Biodiversity and ecosystems are also used for raw materials (such as precious woods), energy (such as fuelwood; Global Goal 7), ornamental purposes (such as trophies), skin and fibre trade, and the pet trade. Overall, competing demands for food, feed, fuel, fibre and raw materials are intensifying pressures on land (UNEP 2012b). While natural resources are being used much more efficiently to produce goods and services, this progress is overwhelmed by increased overall demand, making it unlikely that impacts on ecosystems can be kept within safe ecological limits (CBD 2014). Improved governance and capacity building are crucial to making land use and production systems more sustainable (UNEP 2012b). A review of all aspects of the sustainable use of biodiversity is underway by IPBES (2016d).

Sustainable forest management can allow the production of a continuous flow of forest products and services without undue reduction of future forests productivity and values (ITTO 2004-2014). This is one avenue for limiting the impacts of consumption of both timber and non-timber forest products, while playing a role in reducing greenhouse gas emissions from forests (Global Goal 13). Globally, progress has been made towards sustainable forest management, and 140 nations have policy and legal frameworks in place to support sustainable forest management (FAO (2016a). Forest area under a management plan had by 2010 increased to 2.1 billion ha, distributed equally between forests designated for production and for conservation. Forests internationally certified as under sustainable management now cover 438 million hectares – 11 per cent of global forest area (FAO 2016a). Non-timber Forest Products (NTFPs) are an important aspect of sustainable forest use, with a large body of research focusing on their cultural importance, the role of local markets, the contribution of the diversity of NTFPs to rural livelihoods, and the range of management options, from pure extractivism to monoculture (Sills *et al.* 2011). Existing assessments of the sustainable use of NTFP species (covering only a few of the thousands of NTFP species) show that some are overharvested, while others are still well within their harvest limits (Ticktin *et al.* 2011).

The Convention on International Trade in Endangered Wild Fauna and Flora (CITES) has been monitoring and assessing the trade of wild species since 1973. It provides recent and systematic information on specific internationally traded wild species, which are traded in high volumes or showing sharp increases in trade. Species which are legally traded at low levels, and national trade in species, is not covered, including such trade for food (Global Goal 2). The illegal wildlife trade (as distinct from the legal trade) is estimated to have a value of USD 7 to 23 billion per year (Nellemann *et al.* 2016), and its control is closely related to environmental governance (Global Goal 16). A number of traceability systems have been developed to manage the trade in species and try to prevent illegal and unsustainable use (Mundy *et al.* 2015). However, a recent report suggests that there are millions of species for which international trade is not regulated. Additionally, there are certain cases where these species can be legally traded internationally, even when harvested or exported contrary to national law (UNODC 2016). The report also highlighted that current international controls regulating trade do not extend into national markets, so domestic environmental laws should be expanded to provide protection to wildlife from other parts of the world.

Loss of biodiversity

The relationship between biodiversity, ecosystem functioning and ecosystem services is complex and not fully understood (De Groot *et al.* 2014). There is, however, clear evidence of the central role of biodiversity in the delivery of some, but not all, ecosystem services (Elmqvist *et al.* 2010). For example, recent reviews (Hicks *et al.* 2014) have shown there are an established links between: biodiversity and the primary productivity of ecosystems; biodiversity and pollination services; biodiversity and biological control of pests and diseases of crops; intact forest cover and the reduction of soil erosion; and the presence and intactness of forest ecosystems and water regulation and quality (Global Goals 1, 2, and 6).

Despite global efforts, biodiversity has continued to decline (Tittensor et al., 2014). Cazzolla (2016) has even suggested that the probability of preserving much of the main biodiversity in freshwater ecosystems is very low (Global Goal 6). The decline in biodiversity has been driven by pressures from human activities, such as conversion and degradation of habitats, climate change, harvesting, and pollution (Tittensor *et al.* 2014; Newbold *et al.* 2015). According to Newbold et al. (2016), the current level of biodiversity loss is testing the ability of ecosystems to support human societies as it is beyond the 'safe limit' of proposed planetary boundaries (a framework that defines a safe operating space for humanity; (Steffen *et al.* 2015)).

Global assessments show that, in addition to declines in population sizes, species' extinction risk is also increasing (Cardinale *et al.* 2012; Naeem *et al.* 2012). According to Ceballos et al. (2015), modern rates of extinction are up to 100 times higher than under a 'natural' rate of extinction without human impact. Poaching and illegal wildlife trade has been identified as one of the potential drivers of species extinctions in the future. Therefore, tackling these issues at the appropriate scale could make a significant contribution to preventing the extinction of threatened species (GEF 2014; Lawson *et al.* 2014). There has been an increase in responses to the loss and degradation of biodiversity, including the designation of PAs, managing invasive species, and regulating sustainable harvesting. However, these have failed to reduce the decline, and more effort is needed (UNEP 2012a).

Equitable sharing of benefits arising from the utilisation of genetic resources

The promotion of fair and equitable sharing of the benefits arising from the utilisation of genetic resources, as well as appropriate access to such resources, is an important issue in terms of environment-human interactions. The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilisation, which was adopted in 2010 under the CBD (Greiber *et al.* 2012), is viewed as one of the key instruments in access and benefit-sharing. However, international agreements and regional and national processes focusing on the environment, economy, trade, law and policy (such as multilateral trade rules) also play a role. Since the adoption of the Nagoya Protocol, there has been an increase in research on this topic (Koester 2012).

Agriculture, pharmaceutics (including cosmetics), industrial biotechnology, and the food and beverages industry all make use of genetic resources and associated traditional knowledge (Global Goal 2 and 9). This takes different forms and there are varying amounts of literature produced for each sector (Laird *et al.* 2012). The boundaries between commercial and non-commercial research, and how these are defined, is a contentious area for the different sectors (Chege Kamau *et al.* 2010; Schindel *et al.* 2015). The implementation of access and benefit-sharing requires that mutually agreed terms are negotiated between the user and the provider of the resources. However, only a limited number of internationally agreed definitions exist that provide clear

guidance on the concept of 'fair and equitable' (Morgera 2015a; Morgera 2015b; Morgera 2016).

Invasive species

Invasive alien species are responsible for the extinction of native plants and animals, the degradation of rare and threatened ecosystems and ecological communities, the failure of crops and declining agricultural productivity, the loss of cultivar and animal breed diversity, and damage to property, infrastructure, native fisheries, tourism and outdoor recreation (Global Goals 2, 6 and 9) (IPBES 2016c). The rapidly growing threat that invasive alien species pose to biodiversity, ecosystem services, sustainable development and human well-being is poorly quantified and not well understood by decision-makers (IPBES 2016c). Therefore, IPBES has approved a scoping report for a thematic assessment of invasive alien species and their control on the basis that "invasive alien species constitute one of the most serious and rapidly growing threats to biodiversity, ecosystem services and food, health and livelihood security" (IPBES 2016c).

Mainstreaming

There have recently been increasing efforts towards 'mainstreaming' ecosystems and biodiversity – integrating the conservation of ecosystems and biodiversity into policy, strategies and practices of actors that impact, or rely on, biodiversity. (Redford *et al.* 2015). Important progress has been achieved in incorporating biodiversity values into planning processes and strategies to reduce poverty (Global Goal 1), and in integrating natural capital (the stocks of Earth's natural assets and resources, such as soil, water, air and biodiversity) into national accounts (Global Goal 8). Differences among countries remain, but international initiatives are helping to reduce these differences (CBD 2014).

1.16.4 Knowledge and research gaps

The 5th Global Environmental Outlook (GEO5) report concluded that "adequate information does exist to develop effective environmental policies; data gaps rarely justify inaction" (UNEP 2012a). Despite this a number of gaps in research and knowledge exist. Further research and investigation is needed in the following areas:

Extent and condition of terrestrial ecosystems

- Extent and condition of specific ecosystems (especially drylands and wetlands), as well as the location of degradation and land-use change (including through ground truthing and from long term monitoring) (UNEP 2012a).
- Status, trends and future trajectories of different species and ecosystems, including through the expansion of the IUCN Red List of Threatened Species and ecosystems (Brooks et al, 2015) especially ecological function, economic value, traditional knowledge, and impacts of climate change in relation to, agriculturally important genetic resources (such as cultivated plants, domesticated animals and wild relatives), species experiencing recent rapid declines (such as amphibians and freshwater fish), and migratory species (IPBES 2013).
- Global freshwater biodiversity (Harrison *et al.*), and specific in-lake and near-lake data to enable the assessment of their comparative conditions on a global scale (ILEC *et al.* 2016)
- Socioeconomic drivers of change in biodiversity and ecosystem services and how their impacts can be evaluated and included in decision-making, including impacts of economic incentives, trade, agriculture and forestry (IPBES 2013). For example, information on the sustainability of NTFP harvesting (Ticktin *et al.* 2011) and how the impacts of biofuels varies with type (Sutherland *et al.* 2009).
- Direct pressures and their impacts on biodiversity and ecosystem services, and how they can be managed, including the impacts of climate change (Sutherland *et al.* 2009), invasive alien species (note an assessment on this is being produced) and pollution (IPBES 2013), and technological change (such as how might nanotechnology impact biodiversity) (Sutherland *et al.* 2009).
- Trends in the state of biodiversity in relation to drivers of biodiversity loss (UNEP 2012a).
- Conceptual and technical questions about ecology; for example, the dynamics of environmental change and complex ecosystem interactions (Sutherland *et al.* 2013), including the ways in which species interact with other species (ecological interactions) that are crucial to provide ecological function (such as how defaunation affects seed dispersal and so carbon stocks) (Jordano 2016).

Value and role of terrestrial ecosystems and biodiversity

- The role of biodiversity and ecosystem services in supporting human well-being, including poverty reduction, health, sustainable agriculture, food security and mitigating the effects of natural disasters, and in supporting recovery (IPBES 2013)
- Soil-related processes, impacts and ecosystem services (Montanarella 2015a; Montanarella 2015b).
- Monetary and non-monetary values of biodiversity and ecosystem services, and how these values can be taken into account by governments and institutions. Including cultural, intrinsic and option values, traditional knowledge of values, lost opportunities

through not acting (IPBES 2013) and valuing a broader range of ecosystem goods and services in national statistical systems (UNEP 2012a).
- How the degradation of terrestrial and freshwater systems affect biodiversity, ecosystem services and human well-being, including critical thresholds, and how can these be predicted (Sutherland *et al.* 2009), as well as improved methods for integrated assessment and monitoring of land degradation at catchment scale (Shepherd *et al.* 2015).
- Integrated approaches to spatially explicit modelling and valuing of the loss and recovery of ecosystem services through degradation and restoration (Turner *et al.* 2015).
- Participatory approaches to model development, decision-making and scenario-testing to provide insights into processes and trade-offs.

Management and governance
- Plausible socio-economic development pathways lead to sustainability, and the socioeconomic transformations necessary to achieve these (IPBES 2013).
- Effectiveness of different environmental policy and management approaches (UNEP 2012a), including:
  - species management (e.g. trade in species, cost-effectiveness of different species conservation programmes such as education or habitat management) (Sutherland et al. 2009);
  - trends in and effectiveness of payment for ecosystem services schemes (UNEP 2012a);
  - protected areas, for example, the effectiveness of different types of protected areas and their management costs (Sutherland et al. 2009), as well as, the number and extent of community managed protected areas (UNEP 2012a);
  - ecosystem management, for example, the contribution of areas managed intensively for production to biodiversity conservation at the landscape scale (Sutherland et al. 2009);
  - improved techniques for rehabilitating degraded ecosystems to increase biodiversity and ecosystem services (Rey Benayas, 2009), including improved monitoring of, and empirical research on quantifying, biodiversity, ecosystem service other socioeconomic outcomes of restoration action in order to understanding its full benefits and costs (Wortley et al. 2013).
- The status of access and benefits-sharing and traditional knowledge (UNEP 2012a).
- Importance of organisational systems and processes (including the effectiveness of different mechanisms), as well as social context and change (e.g. impacts of trade, corruption, education) (Sutherland *et al.* 2009).
- Access to data and visualization of data and development of decision support tools, including on specific themes (e.g. sustainable use, poverty reduction, impact of pollution, impact of commercial products and services) and specific types of tool (e.g. scenarios, indicators) (IPBES 2013).
- Information on environmental expenditures, green investments, green Gross Domestic Product (GDP) accounting (UNEP 2012a).
- Identification of capacity-building needs (IPBES 2013) and the in-country expertise and capacity required for data collection, quality assessment, analysis and interpretation on different themes (UNEP 2012a).

Cross-cutting
- Emerging issues identified within different horizon-scanning initiatives, for example: managed bees as transporters of biological control agents; artificial superintelligence; electric pulse trawling; testosterone in the aquatic environment; artificial oceanic islands; and the incorporation of ecological civilisation principles into government policies in China (Sutherland *et al.* 2016)
- Integrating different types of knowledge: natural sciences, social science and indigenous and local knowledge, despite recent increases in interdisciplinary research (Velasco *et al.* 2015)
- Failures of conservation actions.

1.16.5 Overview of networks and funding

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) is the primary body for assessing the state of biodiversity and of the ecosystem services it provides to society, and for undertaking new major syntheses. There are also a large number of collaborative research networks, some of which are focused on more primary research and data collection (such as the Group on Earth Observations and the Global Mountain Biodiversity Assessment). The International Union for Conservation of Nature (IUCN) is the largest network of government and civil society organisations that aims to provide public, private and non-governmental organisations (NGOs) with the knowledge and tools that enable human progress, economic development and nature conservation to take place together. Its members include states and government agencies, large and small NGOs, scientific and academic institutions, and business associations.

The main global sources of funding for work related to life on land include the Global Environment Facility (GEF; which is the main

funding mechanisms for the CBD), foundations such as the Arcus, Moore and Packard Foundations, and national funding such as the European Union Framework Programme 8 or the Council for Scientific and Industrial Research (CSIR) in South Africa.

1.17 GLOBAL GOAL 16: PROMOTE PEACEFUL AND INCLUSIVE SOCIETIES FOR SUSTAINABLE DEVELOPMENT, PROVIDE ACCESS TO JUSTICE FOR ALL AND BUILD EFFECTIVE, ACCOUNTABLE AND INCLUSIVE INSTITUTIONS AT ALL LEVELS

1.17.1 Summary of Global Goal

The overall aim of Global Goal 16 is to promote peace, justice, and effective, accountable and inclusive institutions are at the core of sustainable development. More specifically, it seeks to significantly reduce all forms of violence and related death rates everywhere; end abuse, exploitation, trafficking and all forms of violence against and torture of children; promote the rule of law at the national and international levels and ensure equal access to justice for all; reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organized crime; substantially reduce corruption and bribery in all their forms; develop effective, accountable and transparent institutions at all levels; ensure responsive, inclusive, participatory and representative decision-making at all levels; broaden and strengthen the participation of developing countries in the institutions of global governance; provide legal identity for all; and ensure public access to information and protect fundamental freedoms.

Many countries have enjoyed increased and sustained levels of peace and security in recent decades. Nevertheless, numerous others still face protracted armed conflict and violence, and far too many people struggle as a result of weak institutions and a lack of access to justice, information and other fundamental freedoms (UNECOSOC 2016b). Official data on the relevant metrics are often lacking, or not harmonised (for instance, victims of robbery, homicide and sexual violence), particularly in developing nations, rendering the identification of global trends difficult.

The Millennium Development Goals (MDGs) are considered to have positively influenced development cooperation since the beginning of this century. Yet, one of their weaknesses was the absence of specific goals or targets related to peace, security, human rights and justice. Ironically, violent conflict is considered to be one of the largest obstacles to achieving the MDGs (UNPBSO 2012).

Multilateral environment agreement, as processes for negotiating agreement between countries, are fundamental to supporting international justice and preventing conflict. For example, The Aarhus Convention (1998) grants the public access rights to information, public participation and justice in governmental decision-making processes concerning local, national and transboundary environmental matters.

1.17.2 Overview of main environment-human interactions

Tensions over non-extractive natural resources (for example, the use and availability of water and land) regularly drive conflict, usually on a local level. This may spill over into wider conflict, particularly where grievances are manipulated for political ends at the macro level (OECD 2005). Moreover, the exploitation and illegal trade of natural resources frequently fuels and prolongs armed conflict, especially in countries where laws and institutions have been weakened or have collapsed (UNEP 2009b). Indeed, scarcity of natural resources is strongly related to dysfunctional institutions and poverty (Global Goal 1) (Theisen 2008).

The Millennium Ecosystem Assessment (2005) noted that the harmful effects of the degradation of ecosystem services are sometimes the principal factor causing social conflict. It also highlighted that in order to reverse the degradation of ecosystems while meeting increasing demands for their services needs significant changes in institutions and practices (MA 2005). The effective management environment-human interactions needs effective, accountable and inclusive institutions.

There is growing evidence of the links between environmental problems and social injustices (Goals 5, 10). Environmental damage and degradation often threatens livelihoods, can aggravate tensions, and can increase the number of refugees and internally displaced people (OECD 2005). In turn, this can create further challenges as migration may negatively impact the environment through rapid and unplanned urbanisation and unsustainable agricultural and production systems (Goals 11, 2, 12).

1.17.3 Synthesis of developments in research, innovations and policies

Conflicts and the environment

Increasing competition for diminishing renewable resources, such as land and water (Global Goals 2,

6 and 15), is on the rise, and is compounded by environmental degradation, population growth and climate change (Global Goal 13) (UNEP 2013c). Pressure on water resources, often referred to as 'water stress', has been identified as a major contributor to instability, and can lead to intense political pressures (Global Goal 6) (Wolf 2007). Interstate tensions are exacerbated by water sources (including fossil aquifers and river basins) being shared across international boundaries. Indeed, countries that share rivers have been found to be at higher risk of military disputes (Gleditsch *et al.* 2006).

Evidence of environmental crises resulting in human migration is increasing. These migrants are often labelled 'environmental refugees' (Morrissey 2012). However, this term oversimplifies the multiple factors (i.e. social, economic and political) which underpin environmentally forced migration (Boano *et al.* 2008). While environmental factors are rarely the sole cause of violent conflict (Theisen 2008), over the last 60 years, more than 40 per cent of all intrastate conflicts have been linked to natural resources (Global Goals 6, 14 and 15) (UNEP 2009a). Natural resources can contribute to violent conflicts in three main ways. Firstly, conflicts can be financed via revenues from natural resources, especially from primary commodities like oil, diamonds, minerals and timber. Indeed, tensions over these high-value resources have exacerbated civil wars, such as those in Cambodia, the Democratic Republic of the Congo (DRC), Côte d'Ivoire and Liberia. Secondly, conflicts like those in the Niger Delta have been motivated by marginalisation and environmental damage in regions where the population has not benefited from local natural resource extraction. Finally, violent conflicts, including those in Darfur and the Middle East, have involved disputes over scarce resources, such as fertile land and water (UNEP 2012c).

In future, many experts expect natural resources to become key drivers in a growing number of disputes, with potentially significant consequences for international, regional and national peace and security (UNDPA *et al.* 2015). A recent review suggests anthropogenic climate change already represents a critical driver of human conflicts (Global Goal 13). There is strong causal evidence across all major regions of the world, and predictions indicate that intergroup conflicts could rise by 30 to 60 per cent by 2050 due to climate change (Hsiang *et al.* 2013).

Environmental impacts of conflict

Conflict can often lead to the rapid depletion of natural resources (Global Goals 14, 15). In DRC, there have been persistent problems related to minerals and timber extraction and the discovery of oil and gas reserves under Lake Albert has led to a protracted border dispute between Uganda and DRC. Illegal exploitation of natural resources, such as occurs in DRC, will continue to leave countries and people in poverty (Global Goal 1) (Kanyamibwa 2007).

Decades of conflicts in West Asia have resulted in numerous environmental disasters, including the destruction of infrastructure and agricultural lands, the depletion of natural resources, the pollution of soil and groundwater, and the loss of biodiversity (Global Goals 9, 2, 14,15, 6) (UNEP 2016d). For example, the ongoing Israeli-Palestinian conflict has resulted in around 300 plant species being placed on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (UNEP 2016d). As such, special attention should be given to environmental issues both during and after conflicts (Kanyamibwa 2007) Globalised economies and modern warfare have increased and intensified the scope and magnitude of conflicts in recent years, leading to greater negative impacts on natural resources (UNEP 2013c).

The impact of refugees and internally displaced persons (IDPs) on the environment is significant. Refugees and IDPs have contributed to deforestation, soil erosion, agrochemical pollution, water shortages, abandonment of rural areas, declining health and physical resilience, and unsustainable agricultural and production systems (Global Goals 15, 2, 6, 9,11, 3, 12) (Boano *et al.* 2008). Furthermore, local extermination of individual species, such as elephants in Central African Republic (CAR) and gorillas in DRC, have been associated with refugees and the presence of IDPs (Kanyamibwa 2007). Rapid urbanisation and sprawl caused by immigration can also be a major issue (Global Goal 11). In just two or three years, chaotic settlements in places like Dafur have grown by 200 per cent. Lack of institutional planning and environmental consideration in dealing with refugees is considered to be hindering the advancement of many developing nations (Kok *et al.* 2009).

Natural resources and peacebuilding

Natural resources and the environment can contribute to peacebuilding through economic development and the generation of employment (Global Goal 8). Indeed, cooperation over the management of shared natural resources provides new opportunities for peacebuilding (UNEP 2009a). However, too often, it is considered as an issue to be addressed at a later stage of development, and current linkages with disarmament, demobilisation and reintegration

programmes are relatively narrow given the breadth of opportunities available (UNEP 2013c).

While the way that natural resources and the environment are governed has a determining influence on peace and security, these issues can also contribute to a relapse into conflict if they are not properly managed in post-conflict situations. Preliminary findings from an analysis of intrastate conflicts over the past 60 years indicate that conflicts associated with natural resources are twice as likely to relapse into conflict in the first five years. Nevertheless, fewer than a quarter of peace negotiations aiming to resolve conflicts linked to natural resources have addressed resource management mechanisms (UNEP 2009a).

Law, justice and the environment

Weak governance can negatively impact on the environment. Effective environmental governance at all levels (global, regional, national and local) is critical for the achievement of environmental sustainability and ultimately sustainable development. Environmental Governance comprises the rules, practices, policies and institutions that shape how humans interact with the environment. Environmental justice, the fair treatment and meaningful involvement of all people, regardless of race, colour, national origin and income, with respect to the development, implementation and enforcement of environmental laws, regulations, and policies (US EPA 2016), is essential for achieving equality (Global Goal 10).

International law, in the form of multilateral environmental agreements, provides mechanisms for regulating the impact of states on the environment. A number of international courts, tribunals and arbitrating bodies have been created to decide on states' obligations and responsibilities under international environmental law. Yet, the current international system is not considered to deliver sufficient access to justice for non-state actors (Global Goal 10), or provide a forum that is suitable to hear very technical scientific evidence, which is common in environmental cases (ICE 2011).

The number of national or state level environmental courts and tribunals, have also greatly increased since 2000, and there are currently over 1,200 in 44 countries (Pring *et al.* 2016). Best practice for environmental courts and tribunals include judicial independence, flexibility, use of alternative dispute resolution, comprehensive jurisdiction, open standing, effective remedies and enforcement powers, and unique case management and expert evidence tools (Pring *et al.* 2016). For any environmental legislation or regulation to be effective it requires to be adequately enforced, which can be a challenge in many countries. Examples of good practise in relation to administrative, civil and criminal enforcement include institutional coordination, information sharing, knowledge management, tools, training, monitoring and public engagement (UNEP *et al.* 2014).

Conservation and sustainable management to tackle environmental degradation can risk driving conflict. Stakeholder dialogue and mediation is vital to avoid escalating tensions from the outset (OECD 2005). These issues are not limited by national borders and, therefore, a regional approach to environmental conflict and governance issues is often essential (OECD 2005).

Environmental crime

The opportunities ecosystems provide for future development are threatened by serious and increasingly sophisticated transnational, organised, environmental crime, particularly in areas with poor governance. Such crime includes illegal logging, poaching and trafficking of animals, illegal fisheries, illegal mining, and dumping of toxic waste. It is a rapidly rising threat to the environment, revenues from natural resources, state security, tourism and sustainable development. Combined estimates place the monetary value of all transnational, organised, environmental crime between USD 70 and 213 billion annually (Nellemann *et al.* 2014).

The illegal trade in wildlife is no longer an emerging issue and has been estimated by different sources to be worth USD 7 to 23 billion annually (Wilson-Wilde 2010). It concerns both live and dead specimens that are used for pharmaceutical, ornamental or traditional medicinal purposes, or as food and pets. Illegal harvest and trade includes a range of taxa, such as gorillas, chimpanzees, elephants, tigers, rhinos, Tibetan antelopes, bears, corals, birds, pangolins, reptiles, sturgeon (for black caviar), and a wide variety of other commercial fishery species from the high seas and territorial waters (Global Goals 14 and 15) (Nellemann *et al.* 2014).These crimes represent a significant environmental and economic threat that extends beyond the areas from which the environmental resources are removed. The illegal wildlife trade facilitates the introduction of species to new regions, where they potentially compete with native species for resources, alter ecosystems and destroy crops. It has also led to the introduction of pathogens with the potential to threaten agricultural production, biodiversity and public health (Goals 2, 3, 14, 15) (Smith *et al.* 2009).

The scale of revenue from wildlife trafficking, however, is dwarfed by the income from forest crime, which includes illegal logging. Forest

crime has previously been estimated to represent a value of USD 30 to 100 billion annually, which is 10 to 30 per cent of the total global timber trade (Nellemann *et al.* 2014). The unregulated charcoal trade, alone, involves an annual revenue loss (Global Goal 8) of more than USD 2 billion to African countries. With current trends in urbanisation and demographics, the demand for charcoal is expected to triple in the coming three decades (Global Goal 7). This will generate severe impacts, such as large-scale deforestation, pollution and subsequent health problems (Global Goals 3 and 15) (Nellemann *et al.* 2014). The increased charcoal demand will also strongly accelerate emissions from both forest loss and short-lived climate pollutants (Bailis *et al.* 2015).

Wildlife and forest crime play a serious role in financing other organised crime, non-state armed groups and terrorist groups. For example, ivory provides a significant portion of income raised by militia groups in the DRC and CAR, and is probably a primary source of income for the Lord's Resistance Army currently operating in the border triangle of South Sudan, CAR and DRC (Nellemann *et al.* 2014).

A number of international networks have been established to combat wildlife crime, including International Criminal Police Organization (INTERPOL) Wildlife Crime Working Group and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). However, these networks have not been significantly funded and, instead, predominantly rely on public donations and member contributions (Wilson-Wilde 2010). To counter the illegal timber trade, instruments like the European Union Timber Regulations (2010) have been implemented.

1.17.4 Knowledge and research gaps

Further research and investigation is needed in the following areas:

Conflict and the environment

- The relationship between environmental change and conflict (Boano *et al.* 2008); including the influence of climate change on conflict in varying contexts (Hsiang *et al.* 2013).
- Early warning metrics and global trends (Brown, pers. comm.).
- Threat financing (also this can put researchers in dangerous positions) (Brown, pers. comm.), including the role of charcoal in threat finance (Nellemann *et al.* 2014).
- Empirical frameworks for analysing 'Positive Peace' – peace with justice for all – which, historically has largely been understood qualitatively and subject to value judgment (IEP 2015).
- International consensus on what constitutes a conflict resource (UNEP 2013c).
- Reliable data on the numbers of people migrating because of environmental impacts (Boano *et al.* 2008).
- The identification and mapping of potential environmental 'hot spots', 'tipping points' and migration trends in relation to environmental depletion (Boano *et al.* 2008).
- Effectively protecting the environment during armed conflict (currently, the Geneva Conventions have stringent and imprecise thresholds for demonstrating damage) (UNEP 2009b).

Law, justice and the environment

- The environmental justice implications of climate change impacts and proposed solutions.
- The potential role of green technologies and green businesses in reducing exposures and unequal exposures to the risks of climate change.
- Policy options in response to documented environmental injustice (Mohai *et al.* 2009).
- Potential governance models for areas experiencing degradation and migration pressures (Boano *et al.* 2008).

1.17.5 Overview of networks and funding

There are a range of organisations and networks currently involved in promoting peace and strong institutions. The Foundation Center and the Peace and Security Funders Group reports that 288 foundations made nearly 2,000 peace-related grants totalling USD 283 million in 2013 (Lawrence *et al.* 2016). These include the MacArthur Foundation, which has awarded 1,700 grants totalling more than USD 443 million over the past 30 years; and the Carnegie Foundation, which awarded 70 grants totalling USD 28 million in 2015.

The intergovernmental initiatives in this field include CITES, the International Organisation for Migration, and the UN Environment Programme's (UNEP) Cooperation for Peacebuilding Programme. Since its creation in 2015, the UN Peacebuilding Fund has allocated USD 623 million to support projects in 33 countries to help prevent (re)lapses into conflict and to sustain peace. In the past 25 years, the United States Institute of Peace has awarded around 2,200 grants for research, training and education. The non-governmental agencies in this area include International Alert, Peace Brigades International and Conciliation Resources.

1.18 GLOBAL GOAL 17: STRENGTHEN THE MEANS OF IMPLEMENTATION AND REVITALISE THE GLOBAL PARTNERSHIP FOR SUSTAINABLE DEVELOPMENT

Global Goal 17 is different from the other Goals – rather than being about a specific issue, it focuses on the means for supporting and facilitating implementation of action to achieve the other 16 Goals. Goal 17 covers the cross-cutting issues of finance, technology, capacity building, trade, policy, institutional coherence, multi-stakeholder partnerships, and data monitoring and accountability. Addressing these issues is essential to the achievement of all of the Goals, and to the interactions between all Goals (Part 2). Overall, the cross-cutting issues that are addressed in Goal 17 need to be considered in the context of achieving all of the Goals together as an indivisible whole.

Since Global Goal 17 is of a different nature to the other Goals, the structure of this chapter differs from those for the other Goals. Rather than summarising the recent developments in research, innovations and policies related to Goal 17, this chapter provides an overview of some key issues related to each of the cross-cutting themes highlighted.

Finance

Achieving the Global Goals requires substantial financing. Funding for research, innovation and policy development on environment-human interactions relevant to specific Goals is highlighted in Section 5 of each of the Goal chapters. Several of these funding sources cut across the Goals, so are mentioned in several chapters (for example, the GEF). In addition, sections 1 to 3 of Global Goal 8 highlights the wider need for considering the environment in relation to the economy and green growth. However, to achieve all of the Global Goals, finance needs to be considered in an integrated way across them all. At the Third International Conference on Financing for Development (Addis Ababa, Ethiopia, 13 to 16 July 2015), the Addis Ababa Action Agenda was developed which provides a new global framework for financing sustainable development by aligning all financing flows and policies with economic, social and environmental priorities. It is an integral part of the 2030 Agenda for Sustainable Development, supports and complements the achievement of all 17 Global Goals, and helps to contextualise its means of implementation with concrete policies and actions (UN 2015a). It covers both new finance, and more integrated and effective use of existing finance. Since the Addis Ababa plan was developed, the inaugural United Nations Economic and Social Council (UN ECOSOC) forum on Financing for Development has followed up on the overall theme; Financing for Sustainable Development: follow-up to the Addis Ababa Action Agenda, was held from 18 to 20 April 2016 at the United Nations Headquarters in New York (UNECOSOC 2016c). The forum included a special, high-level meeting with the Bretton Woods institutions, World Trade Organisation and the UN Conference on Trade and Development. At the forum, a new interagency task force – created to report annually on progress in implementing the financing – also presented its first report (UNECOSOC 2016a).

Technology

Technology is essential for supporting the delivery of a variety of aspects of the Global Goals. This ranges from new batteries for energy storage and novel industrial processes for improved energy efficiency (Goal 7), to enhanced agricultural technology for increasing the productivity, efficiency and climate resilience of food production (Goal 2). It is essential that both existing and new technologies are implemented and developed at vastly greater scales than they are currently if we are to achieve the majority of the Goals. This includes the transfer of technologies, for example between countries.

The Technology Facilitation Mechanism was developed at the same time as the Global Goals in order to support their implementation by increasing access to relevant technologies. The mechanism will facilitate multi-stakeholder collaboration and partnerships among Member States, civil society, the private sector, the scientific community, UN entities and other stakeholders through the sharing of information, experiences, best practices and policy advice. It has three components:

- A UN Interagency Task Team on Science, Technology and Innovation for the Goals, including the 10-Member Group of representatives from civil society, the private sector and the scientific community.
- A collaborative Multi-stakeholder Forum on Science, Technology and Innovation for the SDGs (STI Forum)
- An online platform as a gateway for information on existing STI initiatives, mechanisms and programs

Capacity building

Capacity development is generally recognised as being necessary at individual, institutional and societal levels, and action is needed at all three

levels for effective delivery of the full suite of Global Goals. While capacity-building activities have been referred to in earlier sections of the report with respect to individual Global Goals, it is essential to also consider how to ensure that capacity development is implemented in a coherent manner that addresses the Goals together as a package. This may require new approaches. Furthermore, capacity building needs to be effective and targeted, and support national plans for implementing the Goals using a range of approaches including North-South, South-South and triangulated cooperation. Developing capacity to support the achievement of the Global Goals will need to involve numerous institutions, and will include: developing tools and learning opportunities; increasing access to knowledge and communities of practice; building programmes for sharing of experience; and generally improving the ability of stakeholders from public and private sectors to act. A range of organisations are already gearing up to meet this capacity building challenge, including the United Nations Development Programme (UNDP), the United Nations Institute for Training and Research (UNITAR) and the United Nations University (UNU).

Trade

In order to achieve the Global Goals, Goal 17 calls for a universal, rules-based, open, non-discriminatory and equitable multilateral trading system. The Goal also calls for an increase in exports from developing countries and the implementation of timely access for least-developed countries to markets. Since trade fundamentally affects the patters of production and consumption of natural resources, and has many environmental impacts (Global Goals 8 and 12), changes in trading patterns will impact on the environment and the achievement of Global Goals 14 and 15. All parts of the trade routes for all commodities, and potential changes in these systems, can have implications for the environment and the available measures for reducing any potential environmental impacts. A recent review found that literature on this issue exists, but it is fragmented and contains many different assumptions (including regarding market structure and policy efficiency); the review also found that integration of theory with empirical work is rare (Copeland *et al.* 2013). Most progress has occurred when research efforts have coalesced around a theoretical framework, developed its implications, and examined those predictions empirically (Copeland *et al.* 2013).

Systemic issues

Policy and institutional coherence

Policy and institutional coherence can be a substantial challenge. Goal 17 calls for policy coherence for sustainable development, and policy coordination and policy coherence to support global macroeconomic stability. It also notes the need to respect each country's policy space and leadership. The Global Goals are, in themselves, an example of a range of communities coming together around a common plan, and are an important starting point for moving towards coherence. The High-level Political Forum on Sustainable Development is the UN central platform for the follow-up and review of the 2030 Agenda for Sustainable Development and the Global Goals. As the apex platform for the review of, and follow-up to, the Goals, it is central to achieving policy coherence.

More broadly, across different intergovernmental fora, there is ongoing discussion on synergies and coherence in implementation of international agreements at all relevant levels; for example, the second UN Environment Assembly, in May 2016, specifically recognised the benefits to be gained by implementing the biodiversity-related conventions in a synergistic and coherent manner in order to enhance their implementation, efficiency and effectiveness (UNEP 2016a). A growing body of work is also appearing on 'mainstreaming', including 'reciprocal biodiversity mainstreaming'. Reciprocal biodiversity mainstreaming involves integrating biodiversity concerns into national, local and sector plans, policies and budgets in recognition of the potential of biodiversity to achieve desirable development outcomes, and also in recognition of the importance of incorporating development priorities into biodiversity strategies (IIED *et al.* 2015). As a result, mainstreaming can play an important role in policy coherence.

The relationships between the Goals that are discussed in Part 2 (including synergy, conflict and the need for trade-offs between the different areas of global policy related to the Global Goals) are fundamental to creating coherent policies across different sectors and, therefore, the policy and institutional coherence needed to achieve the Global Goals in totality.

Multi-stakeholder partnerships

Since the Global Goals cover multiple issues and have many relationships among them (Part 2), partnerships are especially important for their effective implementation. Global and multi-stakeholder partnerships that mobilise and share knowledge, expertise, technology and financial resources are needed, as are effective public, public-private and civil society partnerships. Various partnerships and networks of research and implementation associated with specific Global Goals are mentioned in Section 5 of the relevant chapter. In addition to Goal-specific networks,

there are also many networks and partnerships that cut across the Goals, such as the Future Earth Knowledge-Action Network on Sustainable Development Goals. The *Partnerships for SDGs* online platform provides global engagement for partnerships devoted to supporting the implementation of the Global Goals. It is both a tool to inform all stakeholders about initiatives carried out by multi-stakeholder partnerships in support of the Global Goals, and a tool for linking progress of those initiatives to various follow-up mechanisms of the 2030 Agenda (UN 2016b). It includes both partnerships focused on individual Goals and partnerships concerned with multiple Goals.

Data monitoring and accountability

In order to successfully implement activities to address the Global Goals there is a need for clear data, monitoring systems and accountability that relate to addressing both the individual Goals and the Global Goals as a package. Therefore, Goal 17 includes a call for support for capacity -building support to developing countries to increase the availability and accessibility of high-quality, timely and reliable data relevant in national contexts. It also includes developing approaches to assessing progress on sustainable development that complements gross domestic product, and building related capacity to implement those approaches including through support for national data policies, and national statistics offices and programmes. The use of natural capital accounting frameworks at the national level is one of the central approaches to monitoring progress towards the Global Goals; such frameworks both complement and move beyond GDP (Global Goal 8).

1.19 CONCLUSIONS

The syntheses of research evidence, key innovations and policies presented for each Global Goal in this report found that environment-human interactions are important for the achievement of all of the Goals. However, the number of environment-human interactions, and the extent to which these interactions need to be considered for achieving each Goal, varies among Global Goals. Figure 3 provides an overview of the extent to which 'action' (such as research, policy, innovation, debate and/or management) required to achieve a Goal will need to address environment-human interactions, with each Goal placed along a qualitative gradient from 'not at all' to 'entirely'. Crucially, none of the Goals occurs at either extreme of this gradient; none can be achieved by action that address only environment or only human issues in isolation. However, for some Goals, action addressing environment-human interactions is likely to form a smaller part of the overall action required to achieve the Goal (Global Goals 4 and 5), whereas for others (Global Goals 13, 14 and 15) environment-human interactions are central to the bulk of action required to achieve all their aspects.

Recent developments in research, innovations and policies related to environment-human interactions were identified across all Global Goals. However, knowledge gaps related to environment-human interactions remain for all of the Goals. Many of the research, innovation and policy developments and the identified knowledge gaps, within individual Goals are interconnected (as highlighted by the number of cross-references between the chapters in Part 1 and explored in greater detail in Part 2).

Recent advances in knowledge, and new networks, have addressed a number of the information needs encountered during the development of the Millennium Ecosystem Assessment (MA) in 2005, including theoretical basis, scales, data and monitoring, policy assessment, economic instruments and linking social and ecological change (Carpenter *et al.* 2006). The theoretical understanding of links between biological diversity and ecosystem dynamics and services has increased in recent years, especially from experimental studies. Likewise, we have furthered our understanding of environment-human interactions relating to the physical environment, such as our understanding of the physical basis of, and expected changes due to, climate change (Global Goal 13). Despite advances in understanding, knowledge gaps remain in many areas, including in relation to understanding the causal relationships between poverty and biodiversity (Global Goal 1), and complex ecosystem interactions and interdependences (Global Goal 15).

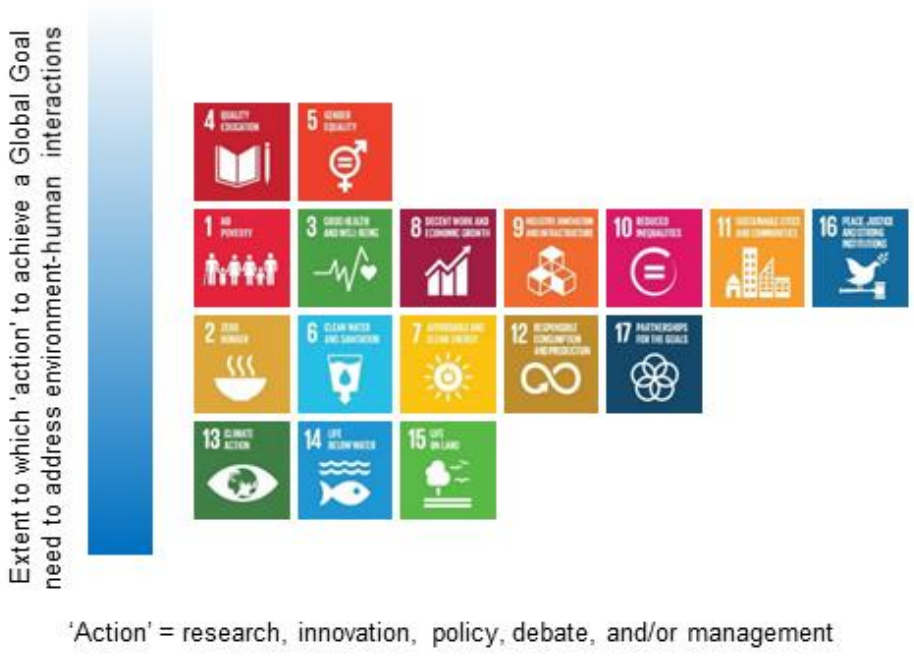


Figure 3. The extent to which 'action' to achieve each of the 17 Global Goals need to address environment-human interactions, scaled on a gradient from none of the 'action' need to address environment-human interactions (top), to all of the 'action' need to address environment-human interactions (bottom).

The importance of scale to environment-human interactions has been noted in recent developments for many of the Global Goals, including in relation to understanding and addressing inequality (Global Goal 10), the impact of urban areas (Global Goal 11), and addressing climate change (Global Goal 13). How to scale up innovations and initiatives to a global level has been identified as a knowledge gap, particularly in relation to inequality and sustainable consumption and production (Global Goals 10 and 12). Furthermore, aligning the scales at which decisions are made with scales at which ecological processes occur, and the temporal and spatial scales at which information is provided, remains a challenge.

Although new monitoring results and initiatives were identified in relation to many of the Global Goals (Global Goals 1, 4, 7, 11, 12 and 14), monitoring was also identified within the data gaps of many of Goals (Global Goals 2, 4, 12,13, 14, 15 and 16). The importance of data, monitoring and accountability for the successful implementation of the Goals is specifically part of Global Goal 17. Likewise, the need for capacity building to support developing countries, including least-developed countries and small island developing states (SIDS), is highlighted by Global Goal 17, with the overall aim to significantly increase the availability of high-quality, timely and reliable data.

Recent developments in knowledge on potential policy approaches and their effectiveness is included in the chapters for each of the Global Goals. Many of the networks identified are aiming to support effective policy development and implementation. However, understanding how to develop and implement effective policies to attain the global-scale changes required to achieve all of the Goals is still a major knowledge gap.

The interconnectedness between environment-human interactions and economics has been an area that has developed substantially since 2005. The concepts of 'natural capital accounting' and the 'green economy' have developed as economic framings of environment-human interactions (Global Goal 8). Additionally, there have been developments in relation to economic valuation and economic incentives related to other Goals. Yet, knowledge on the economic valuation of ecosystems and their services is still identified as a knowledge gap in Global Goal 15. Likewise, knowledge on economic factors in relation to a number of other Goals (including Global Goal 12) has been identified as a knowledge gap, alongside the economics and growth-related gaps listed for Global Goal 8.

By definition, understanding environment-human interactions requires the study of issues through both environmental and social research. The amount of integrated social and environmental research is increasing, and research findings from multidisciplinary research were found in relation to all of the Goals. However, the integration of different disciplines remains a major challenge for developing and synthesising the knowledge needed to address the Global Goals (as was highlighted in relation to the development of the Global Oceans Assessment, Global Goal 14).

Across all of the Global Goals, the syntheses of developments in research, innovations and policies, as well as the knowledge gaps and networks, highlight that there are many cross-cutting issues. Some of these gaps were previously identified by the MA (Carpenter *et al.* 2006; ICSU *et al.* 2008), including: issues of the importance of context in understanding changes and impacts; thresholds and tipping points; human behaviour; and governance and institutions. Although Part 1 is structured Goal-by-Goal, the number of common themes across the Goals, as well as the cross-referencing between the Goal chapters, highlights the extent to which the Goals are interconnected. Filling the knowledge gaps identified for individual Goals is fundamental to achieving all of the Global Goals together. In addition, there are further knowledge gaps and challenges related to the trade-offs, synergies and unintended consequences of the relationships between Goals that need to be addressed to achieve all 17 Goals as an integrated, indivisible whole; this is discussed further in Part 2.

2 *An analysis of the relationships between Global Goals with respect to environment-human interactions*

2.1 BACKGROUND ON RELATIONSHIPS BETWEEN GLOBAL GOALS

The United Nations' (UN) Global Goals for sustainable development, as outlined in the Transforming our World: the 2030 Agenda for Sustainable Development (2015b), present a new and coherent way of thinking about diverse issues related to development, such as hunger, gender and climate change. Economic, social and environmental targets are intertwined in a unified framework of 17 Goals, forming an 'indivisible whole' (Griggs *et al.* 2013; Nilsson *et al.* 2016a). Implicit in the Global Goals logic is that the Goals relate and depend on each other – but, as yet, no one has specified exactly how (Nilsson *et al.* 2016a).

In the real world, decisions and actions, as well as research, innovation and policy, are mostly focused on a single Global Goal, or small subsets of Goals, because of the fragmented landscape of institutions and governance (for example, separate agriculture and climate change departments), and of research funders (such as NERC, ESRC and the Medical Research Council [MRC]). Furthermore, the world's governments may aim to meet individual Goals at national scale, especially those related to human well-being (e.g. Goal 1, 3, 4, 5, 10, 16; Waage *et al.* 2015b). However, because of the interconnectedness among Goals, we need a better understanding of the relationships between Goals, as well as how focusing innovation, policy and decision-making on any one Goal may affect the others. Indeed, we must investigate the trade-offs, synergies and unintended consequences emerging from the relationships between Goals, and the research and knowledge gaps that relate to these.

In Part 2 of this report, we review previous analyses of the relationships between the 17 Global Goals, analyse the relationships between the Goals with respect to environment-human interactions, and highlight cross-cutting issues and approaches in tackling interlinked challenges relevant to research, innovation and policy.

2.2 PREVIOUS ANALYSES

The relationships between Global Goals have been analysed by several groups, representing different stakeholders and using a variety of analysis approaches. These include analyses for UN Divisions (such as UN Department of Economic and Social Affairs), (Le Blanc 2015b) (UNEP 2015e), the private sector (PwC 2016), and the academic community (ICSU 2014 in Le Blanc 2015). These analyses have started to look relationships between 17 Global Goals, such as synergies and conflicts, between the Goals. The available analyses have been approached from a number of different perspectives, primarily from those of the greatest interest to the agency conducting or commissioning the work. This is not surprising, but does not necessarily provide a synthetic overview of how a particular issue might be addressed across all Goals, or how the achievement of one Goal may affect the possibility of achieving elements of another.

A conceptual starting point for analysing relationships between Goals are the concentric layers diagrams of Griggs et al. (2013) and Waage et al. (2015b); examples of which can be seen in Figures 2 and 4). These diagrams propose that the achievement of the Goals shown in the inner circle is dependent on achieving those in the first ring and outer ring. For example, focusing on governance, Waage et al. (2015b) propose that Goals related to human well-being (inner circle) are dependent on Goals that provide the enabling infrastructure for development (the first ring), and Goals that provide the supporting natural systems (the outer ring) (Figure 4). They further suggest that Goals in the same layer, with similar

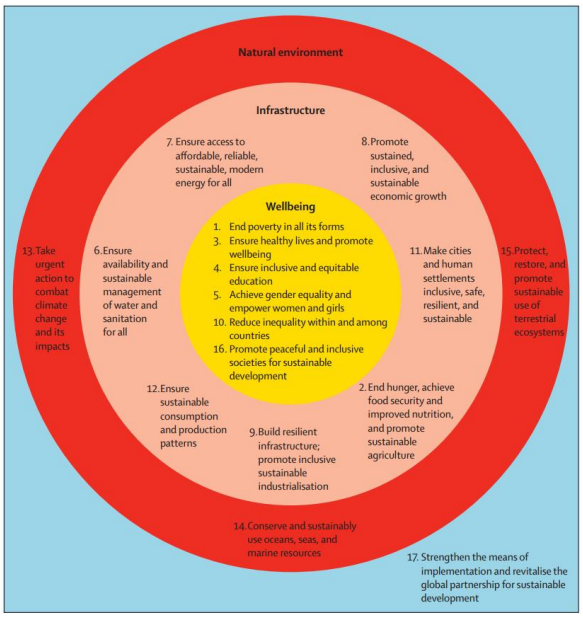


Figure 4. Framework for examining relationships between Global Goals. Note that Goal 17 sits beyond this framework because it is an enabling Goal. From Waage et al. (2015b).

governance structures, should be closely linked in order to realise synergies and remove conflicts. Goals in different layers, however, are likely to require different governance approaches and institutions (for example, from national governments to intergovernmental conventions), when moving from inner circle to outer ring, respectively.

Similar diagrams of the relationships among Global Goals, also using concentric layers, were proposed by Griggs et al. (2013) (Figure 2) and aim to highlight that Goals need to integrate social, economic and environmental dimensions (Griggs *et al.* 2014). More recently, Folke et al. (Folke *et al.* 2016) provided a three-dimensional diagram of concentric layers showing that economies and societies are seen as embedded parts of the biosphere (Figure 5). Rockström and Sukhdev (2016) assert that all Global Goals are directly or indirectly connected to sustainable and healthy food, and suggest that Goals on eradicating poverty (Global Goal 1) and zero hunger (Global Goal 2) require gender equality (Global Goal 5), decent jobs (Global Goal 8) and reduced inequality (Global Goal 10). Yet, a recent representation focused on tackling the interlinkages between the environment and human health shows Global Goal 3 as the only Goal in the inner circle, with the other 16 Goals in the outer layer, directly interacting with Goal 3 and not with each other (Figure 1 in UNEP 2016h).

Other analyses have highlighted much more complex relationships and visualised these using variations on network diagrams. Le Blanc (2015a; Le Blanc 2015b) used textual analysis of the 107 substantive targets of the Global Goals (excluding implementation targets, denoted by lower case letters; Annex A) to identify connections between them (Figure 6 top). This highlights substantial complexity in relationships between Goals. Some Goals have many more connections than others: for instance, Global Goal 12 has connections to 14 other Goals, and Global Goal 10 has connections to 12 other Goals; on the other hand, Global Goal 14 is connected to only 2 other Goals. As this is based on a purely textual analysis, this network diagram

Figure 5. Illustration of connections among Global Goals. 'The wedding cake', developed by Folke et al. (Folke *et al.* 2016), implies that economies and societies are seen as embedded parts of the biosphere.

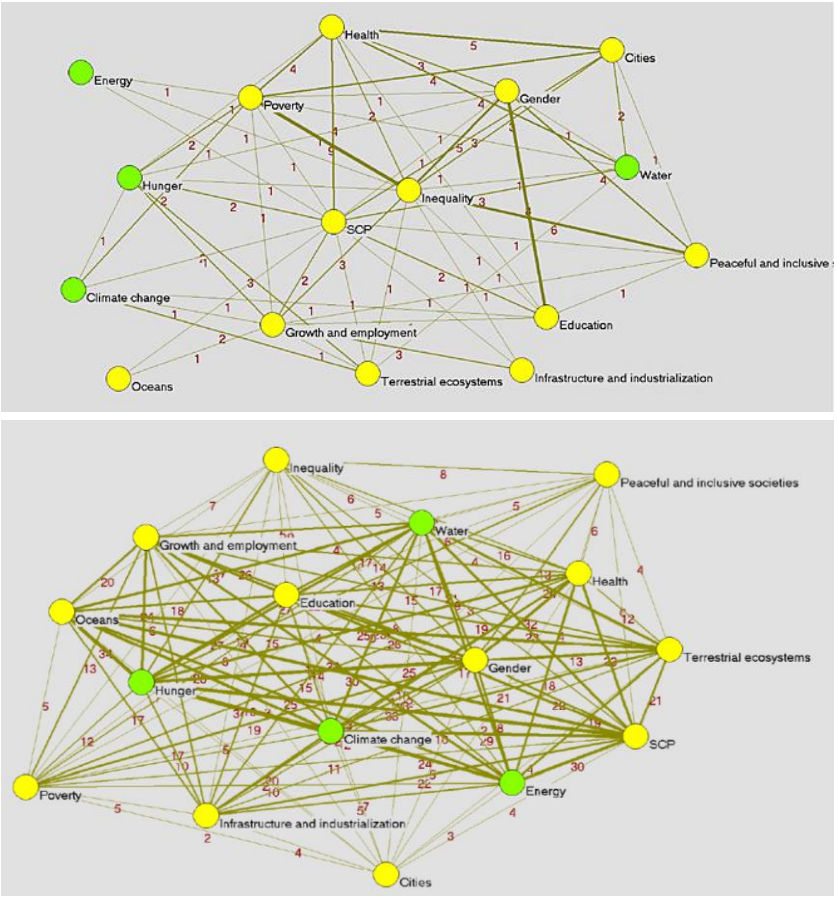


Figure 6. Links between the 16 Global Goals based on (top) a textual network analysis of 107 targets (Figure 2 from Le Blanc 2015), and (bottom) based on expert opinions by ICSU (Figure 5 from Le Blanc 2015). The numbers on the vertices indicate the number of targets linking different Goals (circles). Colours of Goals are used for illustration only and do not represent specific groupings. (Note that there are fewer links starting from Global Goal 11 compared to other Goals (bottom) as this analysis did not assess targets under Goal 11).

does not capture some of the less explicit aspects of the targets and, therefore, omits relationships shown by more 'interpretive' approaches. For example, ICSU (2015) used a consultative approach to assess relationships and found more links and more complexity in relationships among the Goals than the textual analysis based on targets (Figure 6 bottom). Others have focused on subsets of Goals, such as the 'nexus' of water, energy and food, and the interactions among these subsets (Ritz 2015; Weitz *et al.* 2015).

Providing guidance for businesses to navigate the Global Goals, PwC (2016) identified what it terms "the key links to other SDGs [Global Goals]" for each Goal (Figure 7). This provides a more restrictive subset of relationships between Goals. Other, ongoing initiatives are currently examining relationships between Goals, such as the Future Earth Sustainable Development Goals Knowledge Action Network (Future Earth) and ICSU (Nilsson *et al.* 2016a; Nilsson *et al.* 2016b).

Each of the analyses above is useful for the purpose that they were completed. Because every analysis has been looking at the relationship between Goals from a different perspective (different methods and different stakeholders, although specifics of these are often not reported), there are no consistent patterns in the number, or importance, of the relationships between Goals.

The environment is recognised as fundamental for the achievement of many, or all, of the Global Goals by many analyses (UNEP 2015e; Waage *et al.* 2015b; Folke *et al.* 2016), and has been identified as an emerging issue requiring investigation (Müller *et al.* 2016). However, none of the analyses focus on environment-human interactions relevant to the relationships between Goals, and none focus on the research, innovation and policy evidence and gaps relevant to the relationships between Goals. Environment-human interactions are regarded as cross-cutting through the Goals, but this has not been fully elaborated on. There may also be a need for environmental safeguards to be put in place, so that, as one Goal is being achieved, there are no dramatic (intended or unintended) environmental consequences

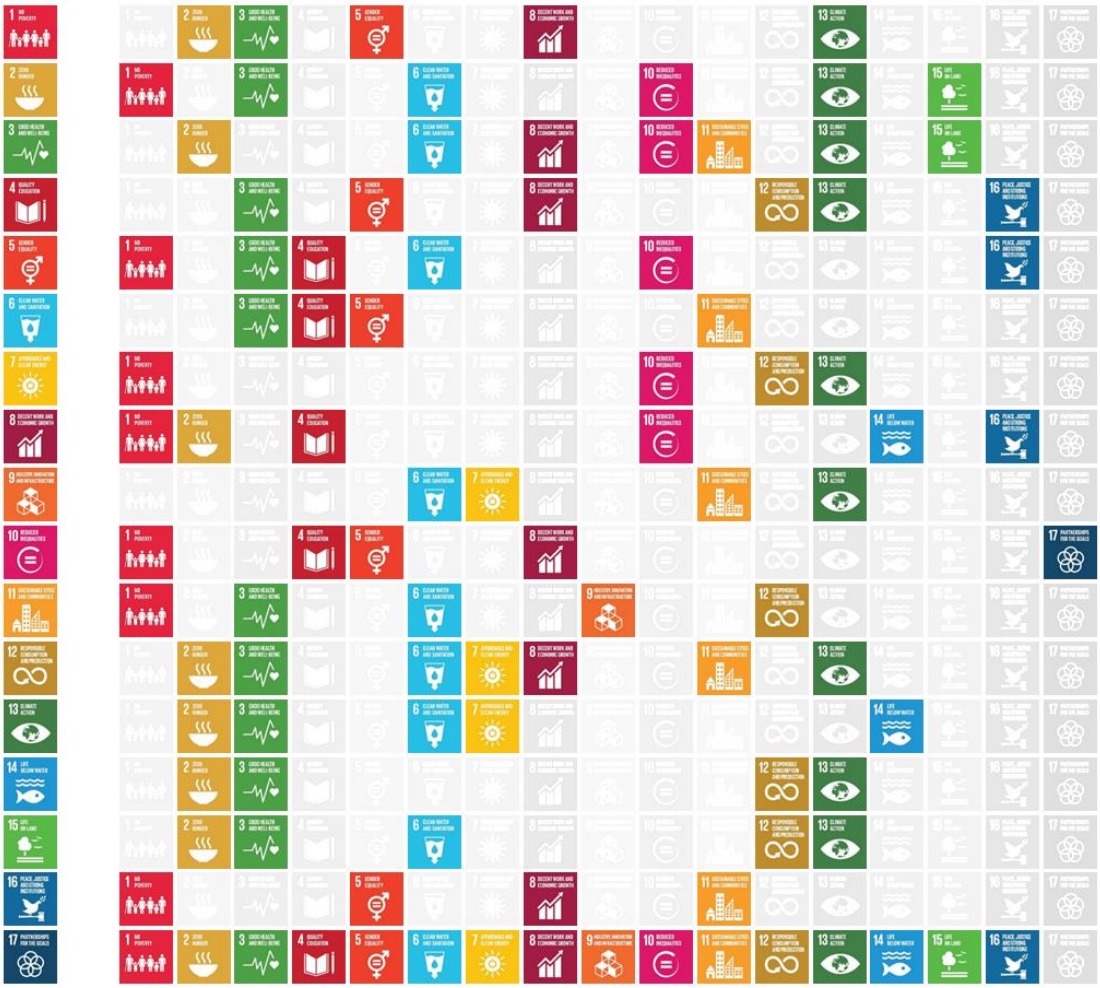


Figure 7. PwC's assessment for businesses of the Global Goals required for the achievement of other Goals. Simple scoring of the importance of all Goals (columns) for the achievement of individual Goals (rows) is used (PwC 2016).

2.3 ANALYSIS OF THE RELATIONSHIPS BETWEEN GOALS WITH RESPECT TO ENVIRONMENT-HUMAN INTERACTIONS

A core premise of the Towards a Sustainable Earth: Environment-human Systems and the UN Global Goals (TaSE) initiative is that the interactions between the environment and humans play a central role in sustainable development. Therefore, environment-human interactions can be expected to mediate progress towards the Global Goals, and to play a critical role in the decisions and actions designed to achieve them. Environment-human interactions will also determine the way any given action influences progress towards multiple Goals, as well as the links between Goals.

Furthermore, although the Goals form an indivisible whole, and progress towards them will require a holistic approach, it remains the case that real-world decisions and actions tend to address more specific problems and opportunities, often at national or smaller spatial scales. Thus, it is crucial to understand how the influence of those decisions on environment-human interactions may affect the multiple dimensions of progress towards sustainable development, as well as the interdependencies, co-benefits and trade-offs across environment-human dimensions of the Goals.

Given the complex and multi-dimensional character of the relationships among Goals, distinguishing those relationships between Goals that are most affected by environment-human interactions is challenging. It is also crucial to the TaSE objective of prioritising and mobilising resources for research and innovation that addresses environment-human interactions crucial for sustainable, resilient human development. All relationships among the Goals are, to some degree, underpinned and affected by both societal (human-human) and environment-human interactions. Some insights on where the latter are especially important can perhaps be gained by

Box 2. Relationships between Global Goals where environment-human interactions are especially influential (the 20 darkest cells in Matrix B of Figure 8, see p. 91)

Environment-human focused action to address a given Goal:	influences potential to achieve another Goal:
2 Zero hunger	6 Water
2 Zero hunger	14 Oceans
2 Zero hunger	15 Land
6 Water	2 Zero hunger
6 Water	3 Health
6 Water	15 Land
7 Energy	2 Zero hunger
7 Energy	13 Climate change
8 Economic growth	15 Land
12 Consumption	14 Oceans
12 Consumption	15 Land
13 Climate change	1 No poverty
13 Climate change	2 Zero hunger
13 Climate change	6 Water
13 Climate change	7 Energy
13 Climate change	14 Oceans
13 Climate change	15 Land
14 Oceans	2 Zero hunger
15 Land	2 Zero hunger
15 Land	13 Climate change

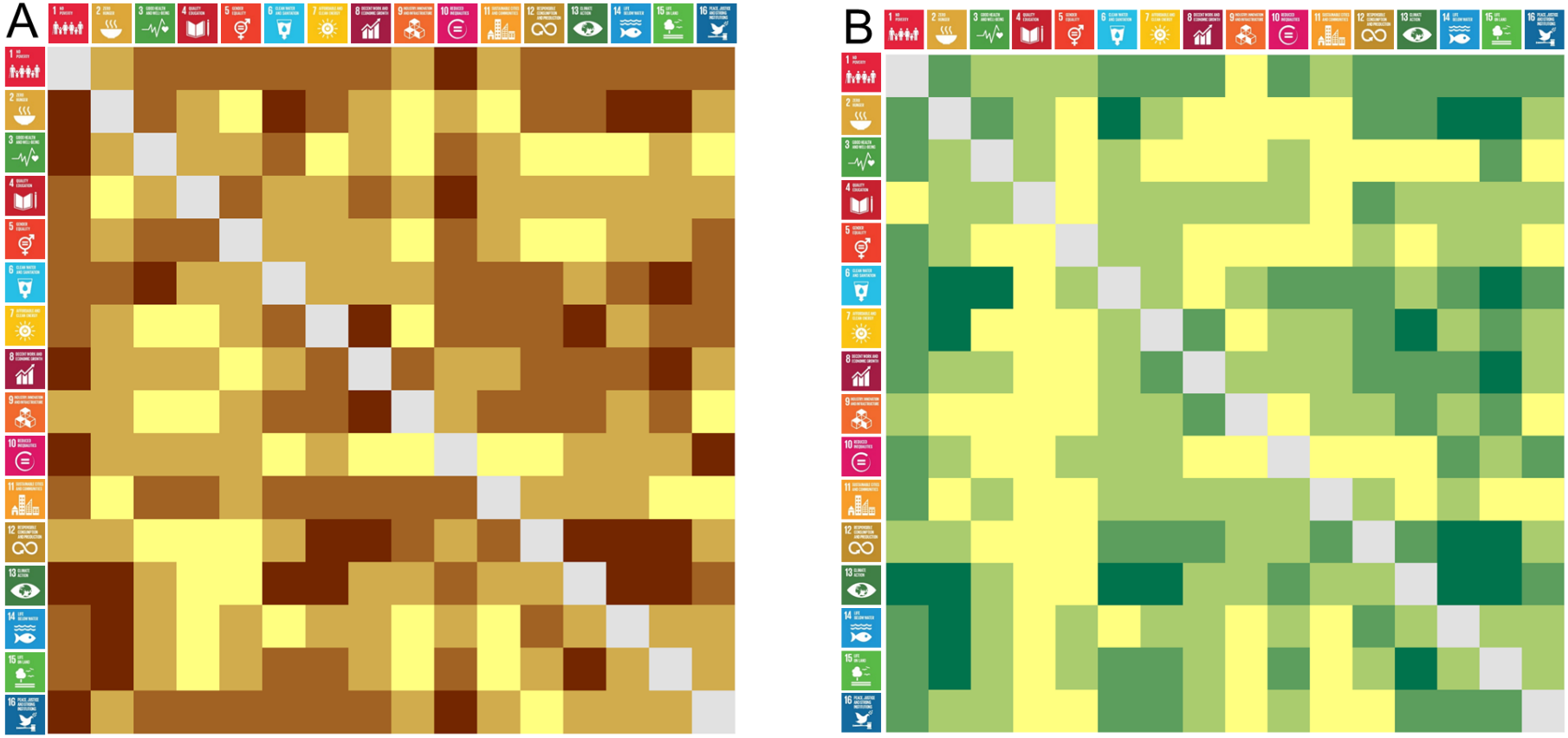


Figure 8. Simplified pairwise analyses of the relationships between Global Goals, based on the assessment by a small expert group of the degree to which 'action' to achieve each Goal (rows) is likely to affect the achievement of other Goals (columns), where 'action' is considered to encompass research, policy, innovation, debate and/or management. (A) Matrix of relationships between 16 Global Goals considering all possible action addressing both human-human and environment-human interactions; (B) Matrix focusing on action related to environment-human interactions only. The darkest cells in each row are those where the bulk of action directed at achieving a Goal (row label) will have the strongest influence (either positive or negative) on the potential for achieving another Goal (column label). For example, much of the action that might be used to achieve health-related Global Goal 3 (e.g. vaccination and sanitation programmes, health education, vector control, and research to support these) is likely to affect (either positively or negatively, depending on what it is and how it is implemented) the achievement of all other Goals to some degree (row 3, Matrix A). However, action to achieve Global Goal 3 may have particular importance for the potential for achieving Global Goal 1, and also Global Goals 6 and 10. Regardless, only a subset of that action addresses environment-human interactions (shown as paler tones in the equivalent row in Matrix B). The darkest cells in each of the Goal columns identify those Goals (rows) that have the greatest influence on the potential to achieve that Goal. For example, the potential to achieve Global Goal 6 is likely to be especially influenced by environment-human focused action for Global Goals 2 and 13. Refer to Box 0.1 for identification of the Global Goal icons used in the row and column labels

examining a simplified, pairwise view of the relationships between the Goals. This can be done with or without a 'lens' that focuses attention on environment-human interactions and the influence that action (research, policy, innovation and/or management) towards one Goal, may have on the potential for achieving others (Figure 8).

In addition to attempting to tease out the environment-human aspects of the relationships between Goals, this approach differs from previous analyses because it focuses on the influence of action (including research) to achieve a Goal and takes into account both positive and negative influences on other Goals. As a result, not all pairwise relationships are equally strong in both directions. For example, a wide range of action may be taken to reduce poverty (Global Goal 1), but not all of this will contribute to addressing hunger (Global Goal 2); whereas, almost all action directed towards reducing hunger (Global Goal 2), will likely contribute to reducing poverty (Global Goal 1).

Comparing the two matrices in Figure 8 shows that there are, indeed, some differences associated with focusing solely (or primarily) on action related to environment-human interactions. For example, when environment-human interactions are the focus, action to achieve affordable and clean energy (Global Goal 7) may have a stronger influence on the potential to achieve less hunger (Global Goal 2; Figure 8B), than when all action is considered (Figure 8A). This is because action focused on energy often addresses technological solutions that may, or may not, directly influence environment-related aspects of food security (though, in principle, any form of energy efficiency may enhance food production). Similarly, addressing environment-human interactions is only part of the action required to make progress on health and well-being (Global Goal 3), and may have less influence on the achievement of gender equality (Global Goal 5) than the full range of health-related action.

The darkest cells in Matrix B of Figure 8 highlight those relationships among Global Goals where environment-human interactions may be most influential. These (Box 2) are some potentially important foci for research, innovation and policy focused on environment-human interactions. Selected examples, and their associated gaps in knowledge and evidence, are illustrated in Boxes 3 and 4. Further exploration of the remaining relationships could help to identify and prioritise a more comprehensive set of research, innovation and policy needs.

2.4 MULTI-DIMENSIONAL RELATIONSHIPS

The analysis of pairwise relationships between Global Goals presented here provides a starting point for evaluating the influence of environment-human interactions on the relationships between Goals. However, it is important to recognise that relationships will not only be between two Goals. Relationships can also be three-way, four-way, and potentially up to 17-way, when considering interactions among all Goals. An example of a three-way relationship is between Global Goal 7 (energy), Global Goal 2 (food) and Global Goal 12 (climate change). Firstly, action on energy impacts directly on food through direct competition for land for energy and food production, and also through relationships with climate change. Secondly, energy use affects the production of greenhouse gas emissions and, therefore, impacts on climate change. In turn, combatting climate change also impacts on agriculture and food production. Thirdly, action on energy can indirectly impact on climate change via impacts on the food sector, such as affecting emissions from agricultural production and land-use change. If all of the different potential relationships in all different directions between all three Goals are considered, there are a total of 15 possible links (Figure 9). This highlights the probable complexity in relationships among Goals and the need to prioritise key interactions for in depth analysis.

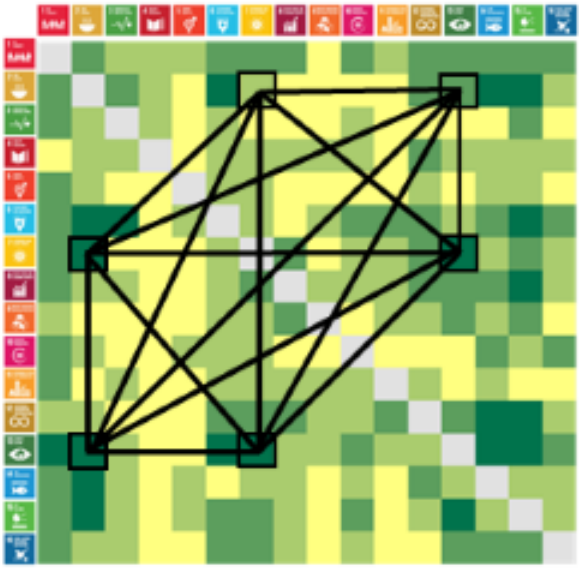


Figure 9. The complexity of considering a three-way relationship between Global Goals 2 (food), 7 (energy), and 13 (climate change). Outlined squares highlight all possible two-way relationships between the three Global Goals. Lines highlight the three-way relationships in terms of how the 15 two-way relationships for all three Global Goals could be connected.

Box 3. Influence of action to end hunger (Global Goal 2) on achieving clean water and sanitation (Global Goal 6).

Overview and research evidence
Action (research, policy, innovation, debate and/or management) that addresses environment-human interactions to make progress towards ending hunger (Global Goal 2) can have major influence (both positive and negative, depending on the action and how it is implemented) on the potential for achieving clean water and sanitation (Global Goal 6). Such action is likely to include changes to agricultural practice (for instance, managing pollination services, pest control, managing for resilience to natural disasters, water use and irrigation, and pollution control) and agricultural expansion (affecting land conversion and resource use), as well as changes to wild food collection. Depending on how altered agricultural practices are implemented, they may have a large effect on the availability of water and its quality; for example, management that reduces or increases runoff will affect erosion, sedimentation, eutrophication and agrochemical pollution. Research has highlighted that agriculture currently accounts for 70 per cent of global freshwater withdrawals (FAO 2012), and that the agricultural water pollutants of most concern are nutrients (nitrogen and phosphorous) and pesticides (insecticides, herbicides, fungicides and bactericides (Turall 2012)). Failure to manage agricultural water use as part of agricultural expansion and intensification to achieve Global Goal 2 could make it harder to achieve the water supply and management aspects of Global Goal 6.

Knowledge and evidence gaps from Part 1 (and beyond)
The relationship between agriculture and water has been highlighted in the knowledge and evidence gaps for Global Goals 2 and 6. The key gaps identified in Part 1 that are relevant to the interaction include:

- Agricultural water use needs further investigation, including: higher-resolution mapping of soils and groundwater; adaptation of cropping systems; and practical forecasting of drought and/or flood (FAO 2011b).
- Improving information systems on groundwater resources and flows should be the priority for all countries using, or planning to use, groundwater for irrigation, and aiming to better enforce policies on sustainable use (OECD 2015a).
- Agricultural policy incentives should avoid supporting production decisions that increase the exposure and vulnerability of agricultural systems to droughts and floods (OECD 2016b).
- Ensuring water rights that reflect water availability within sustainable limits is a prerequisite to any coherent policy on managing droughts in agriculture (OECD 2016b).
- To address water quality issues from agricultural pollution, countries must: enforce compliance with existing water quality regulations; stress the Polluter-Pay Principle to reduce water pollution; compare cost effectiveness of policies; and improve the spatial targeting of policies (OECD 2012).

Box 4. Influence of action to achieve affordable and clean energy (Global Goal 7) on ending hunger (Global Goal 2).

Overview and research evidence
All energy sources (fossil fuels, hydro, wind, solar, biofuels) are derived from the environment and their use has impacts on the environment. Thus, much of the action to ensure universal access to affordable, reliable and modern energy services, and to expand renewables and address energy efficiency, will relate to environment-human interactions. This includes action to increase renewable energy which may require substantial land area, such as hydropower reservoirs, solar farms, windfarms and for growing biofuel feedstocks. Such action may have significant impacts on the potential to achieve Global Goal 2 due to competition for land. For example, the production of biofuels based on food crops has contributed to food-price increases, including the 2007 to 2008 global food crisis, and is increasingly seen as a threat to food security (Timilsina 2014). The use of all energy supplies can also impact on food prouction through the pollution they cause. On the other hand, increases in energy supplies and efficiency may enhance food production. Therefore, action on the expansion of renewables and providing access to modern energy services may have a critical role in impeding or supporting the achievement of Global Goal 2.

Knowledge and evidence gaps from Part 1 (and beyond)
The potential use of marginal and degraded land to produce biomass for energy generation, is highlighted as a knowledge and evidence gap that is relevant to Global Goal 7 (FAO 2008). It is a key area for research and innovation, and could play a major role in mediating the impacts from energy development on food production.

2.5 CROSS-CUTTING FACTORS

A number of cross-cutting factors can shape both the relationships among Global Goals, and the ways in which action leads to the achievement of individual or multiple Goals. These factors need to be considered regardless of whether the focus is on environment-human related action, or on all action to achieve the Global Goals. These factors, which also affect the prioritisation of topics for research, include: scales of action and impact, both spatial and temporal; context for the action, whether local or other; the (multi) directionality of the relationships among Goals; thresholds and tipping points; the number and types of people affected (global population); human behaviour; governance, institutions and power; existence and accessibility of different types of knowledge; and the feasibility of obtaining and scaling-up research results by 2030.

Scale

Both spatial and temporal scale are important factors mediating the relationships among Global Goals, and the outcome of action intended to achieve them. Action taken at one spatial scale (e.g. regional) to support the achievement of one Goal, may have impacts at other scales (e.g. local); furthermore, it may have benefits at one scale, but adverse impacts at another. Impacts may also occur at other locations (for instance, through teleconnections) that affect overall progress towards that Goal or towards other Goals. For example, regional water management programmes (Global Goal 6) can affect water availability at specific locations both within and outside the region, and either positively or negatively, depending on their design, thus possibly affecting progress towards ending hunger (Global Goal 2) at either scale. It is also the case that impacts at local scales often cannot be aggregated as a measure of broader-scale outcomes. Furthermore, the timing of action, and the temporal scales of outcomes relevant to different Goals, may vary. Immediate outcomes of action potentially differ from longer-term impacts both in their relevance to particular Goals, and in whether their effects are predominantly positive or negative. For example, drilling boreholes may provide drinking water in the short term (addressing Global Goal 6), but, in the longer-term, it may lower the water table and reduce access to drinking water (Global Goal 6), and negatively affect agricultural production (Global Goal 2) and natural vegetation (Global Goal 15). Some of these differences arise from gaps in available knowledge and link to the feasibility of filling those gaps. Robust and manageable frameworks are needed to assess the potential impacts of action on progress towards one or more Goals at multiple scales.

Context

The choice and effectiveness of action related to Global Goals are strongly dependent on the context in which it will be implemented. Action that is effective in one context, may have much less relevance in another, and this variation can have important implications for the relationships among the Goals. For example, local concerns may mean that some changes to agricultural practice or incentive programmes are less welcomed in some locations and, therefore, may have different implications for the scaling of progress towards individual or multiple Goals. Understanding the existing local, national and regional political, economic, social and cultural landscape within which the Goals will be pursued will be vital to effective action and understanding variations in the relationships among the Goals. This builds on existing institutions, norms and ways of doing things, rather than the Global Goals being considered as an external imposition.

Directionality

Differences among options for action, as well as variation in scale and context, mean that relationships among Global Goals may encompass both complementarity and conflict. Some action in support of one Goal may contribute to the achievement of other Goals, while other options may impede progress. Visualising this, and understanding its implications, is challenging. A good knowledge-base and frameworks are needed to enable decision-making to take account of the range of possible outcomes and their implication for progress towards all Goals. As noted below, robust governance systems are also needed in order to identify areas of potential conflict and synergy, and to address them in inclusive and sustainable ways. Where goals around tackling hunger, improving energy access and improving access to water are in tension, policy needs to anticipate and address trade-offs across these areas and arrive at effective compromise solutions. For example, the pursuit of biofuels to help improve energy access may require land that could be used for growing crops to tackle food insecurity, and may require high inputs of water that conflict with local community demands for access to that water to meet their own needs. Understanding these interrelationships and linkages is a research challenge. Acting upon them in inclusive and sustainable ways is a policy challenge.

Thresholds and tipping points

Although change in social-ecological systems may be linear and gradual under some circumstances, there is increasing evidence that unsustainable use and other factors may mean that thresholds are crossed, or tipping points reached, prompting abrupt change and transition to novel states. These tipping points may vary temporally

and spatially, and between different systems. Thresholds and tipping points are not well understood or known, which makes it difficult to account for them in anticipating outcomes of action to achieve the Global Goals. In some cases, action to advance progress on one Goal, may generate a tipping point or system transition that could dramatically affect the ability to achieve another Goal. Improved knowledge of thresholds and tipping points in the context of the Goals will be crucial to their achievement.

Population

The number of people affected by action to achieve the Global Goals varies with the type, scale and location of action and associated demographics. The total number of people involved, and the global population growth rate, will affect the relationships among Global Goals. Those relationships may differ substantially between a business-as-usual world, with a slowly declining population growth rate, but increasing overall population, and other possible population scenarios up to 2030 and beyond.

Human behaviour and social norms

The effectiveness of any action to achieve a Global Goal will also be determined by established patterns of human behaviour and the acceptability of the action according to the social norms of different societies and contexts. Frequently, collective action towards collectively desirable outcomes (such as reducing climate change, or avoiding biodiversity loss) is not readily achievable, and there are few incentives for individuals to act alone (Nyborg *et al.* 2016). Change in behaviour and norms may affect the relationships among Goals. Social tipping points may exist where negative behaviours turn into virtuous behaviours, or when people become more willing to choose a widespread behaviour (for instance, when the majority of people are vegetarian, the most common diet [the 'norm'] becomes the most convenient and may spread, with implications for Global Goals 2, 3, 13, 15 and 16) and follow behaviours that are observable (such as watching others recycle) (Nyborg *et al.* 2016). At the same time, infrastructures shape available individual choices and normalise particular patterns of behaviour and consumption, so issues of 'lock-in' need to be addressed alongside individual behavioural change and shifting social norms (Newell *et al.* 2015).

Governance, institutions and power relations

The types and effectiveness of governance, and the identity and structure of institutions involved, play a crucial role in determining the feasibility and effectiveness of action to achieve Global Goals, and may alter the relationships among Goals. The roles, characteristics and preferences of different actors, including civil society, vary widely between countries and scales, and with local context. Understanding the impacts of these differences is crucial (Keane 2016), as is recognising the variation and role of power relations among stakeholders in determining outcomes (Newell 2008). Achieving multiple Goals simultaneously when they touch upon so many sectors, and where such a plurality of institutions are involved in their governance, creates enormous challenges of coordination. These coordination challenges are both horizontal (between institutions at the global, regional and national levels, different agencies and government ministries have to work together) and vertical (coordinating across levels, from the global to the local, to ensure action at each level is supportive of collective efforts to achieve the Goals). Effectiveness of, and variation in, such coordination can potentially alter relationships among the Goals. Likewise, the capacity and ability of societies to deliver on the Goals will be highly affected by the strength of state institutions and the resources they have to implement ambitious programmes; by the extent to which functioning markets can be used as vehicles for achieving Global Goals; and by the extent to which a vibrant civil society exists that can be mobilised towards raising awareness about Global Goals and acting as an agent for delivering projects and initiatives intended to realise them.

Knowledge existence and accessibility

Perceptions of the relationships among Global Goals, and decisions on the design and implementation of action to achieve them, are influenced by the state and accessibility of knowledge on relevant issues and processes. This includes both scientific knowledge (from natural and social sciences, and interdisciplinary approaches) and indigenous and local knowledge. It also includes advances in knowledge and innovation arising in the private sector, much of which may be protected by patents or confidentiality agreements that limit their accessibility; for example, pharmaceutical or biotechnological advances are often closely guarded. The amount, availability, relevance and relative importance of each of these types of knowledge differ among the Goals, and between different locations, contexts and groups of actors. Each knowledge type may provide different perspectives on appropriate courses of action and their likely outcomes for different Goals. Approaches that integrate knowledge from these different sources may provide further insights.

Technology

The availability of technological solutions to specific challenges also varies among the Global Goals, and among countries and contexts. Even

where relevant technologies already exist, financial, intellectual property rights and other barriers, including social norms, may limit their deployment. Thus, innovative solutions that help to achieve the Goals will need to include not only new and emerging technologies, but also strategies and means for deploying them. Effective developments in these respects are likely to affect the action taken to achieve Global Goals and, therefore, the interactions between Goals.

Feasibility of obtaining and scaling-up research results by 2030

Where knowledge gaps exist, the time required to develop, resource and implement programmes of research to address them may be significant. Further time will be needed to integrate the results into decision-making and act on them at a sufficient scale to make a measurable difference to established trajectories. Collaboration among the countries and diverse stakeholders that have embraced the Goals will bring a greater collective effort to bear on these challenges and may help to speed advances. Variation in the time requirements for progress will affect both the action taken, and the relationships among the Goals.

2.6 APPROACHES TO TACKLE INTERLINKED CHALLENGES

Several approaches, practices, and research communities have emerged that attempt to tackle interlinked challenges facing humanity in the 21st century. These contribute to 'sustainability science', "a solution-oriented arena that transcends disciplinary boundaries and seeks to involve non-scientists in resolving the complex, multi-dimensional problems facing humanity" (Abson *et al.* 2016). Here we provide short overviews of some of these approaches and communities, including nexus thinking, pathways, leverage points, indigenous and local knowledge, integrated environmental assessment and integrated modelling.

Nexus thinking

'Nexus thinking' is a recognition that any solution for one problem, for example water, must consider other related problems. The idea of 'the nexus' has been put forward by several people, each with their own agendas and perspectives, and for multiple interconnected issues, such as water-health, energy-growth, climate change-migration-conflict, population-poverty-environment (Camp 1990) (Ozturk 2010). Most recently, in the wake of the food price shocks in 2007/08, discussion of the nexus paradigm around water-energy-food-environment gained momentum. Nexus thinking can help bring researchers, policy makers, business leaders and civil society together to improve decision making across multiple sectors. Some argue that the nexus needs to be framed more broadly, explore the interactions of ecological, social and technological systems across scales, and recognise diversity of knowledge and role of politics (Allouche *et al.* 2005).

Pathways

The 'pathways approach' is intended to guide thinking and action around complex sustainability challenges (Leach *et al.* 2007). The approach proposes thinking about any given issue in terms of complex, dynamic and interacting socio-ecological systems that can change along various pathways. Framings of such complex systems, or sets of issues, are influenced by the thinker's background, occupation, status in society, etc. These various framings will lead to different narratives about the same system and, ultimately, different decisions and action being taken, i.e. multiple pathways exist. Recognising that the framings and pathways of powerful actors and institutions can become the dominant approach for channelling action, the 'pathways approach' aims to include non-obvious potential pathways or those currently blocked by local circumstance (Leach *et al.* 2007). Political and institutional relationships, including those of power and/or knowledge, are crucial in shaping particular framings of system dynamics, and in shaping the system's dynamics and dominant pathways. In considering multiple framings, pathways towards more plural and dynamic sustainable systems are likely to emerge.

Leverage points

Systems-thinking has been used to consider complex issues in many contexts, including in economics and social sciences. Using an integrated, system-oriented approach can help navigate social-ecological complexity and transcend disciplinary boundaries. Leverage points are system properties where a small shift can lead to fundamental changes in the system as a whole (Meadows 1999). These points can be used to target interventions that address ultimate causes of or barriers to sustainability, rather than just tackling feedbacks (interactions between elements of systems) or parameters (characteristics or physical elements of systems) (Abson *et al.* 2016). Three realms have been proposed as containing important leverage points for sustainability transformation: (i) the role of institutions and institutional decline and failure in systemic change; (ii) people's connections to nature and their influences on sustainability outcomes; and (iii) knowledge production and use in transformational processes (Abson *et al.* 2016). Furthermore, these three realms of leverage interact with each other and understanding such

interactions may help us to comprehend transformational change.

Indigenous and local knowledge

It has been suggested in many fora that local people have a good grasp of the complexities of their environments and their relationships with them. In order to cope and adapt to change, they often rely on traditional knowledge, cultural values and customary institutions. These forms of knowledge may contribute to the integrated solutions needed to effect transformation change at local levels and beyond (UNSAB 2016). Indigenous people's local and context-specific knowledge already supports many communities to develop and successfully implement sustainable land management in their territories (Mistry *et al.* 2016). Indigenous and local knowledge systems can provide valid and useful knowledge to enhance our understanding of the management of biodiversity and ecosystems for human well-being (Tengö *et al.* 2014). Therefore, involving local and indigenous populations is key to effective environmental management and governance (Brondizio *et al.* 2016). Recognition, protection and promotion of indigenous and local knowledge strengthens economic, environmental, social and cultural resilience within societies, and forms the knowledge base for addressing critical sustainability problems (UNSAB 2016).

Integrated environmental assessment

An integrated environmental assessment is a critical evaluation of the state of knowledge on a particular topic involving the analysis, synthesis and critical judgement of information by experts from different disciplines among the natural and social sciences (Ash *et al.* 2010). Traditionally assessments have been based on published peer-reviewed literature, but recently have drawn on grey literature and other knowledge systems. The process underpinning integrated environmental assessments is also of value, as it provides an opportunity for increased engagement among experts, decision-makers and other stakeholders long before the final assessment products are produced (Ash *et al.* 2010).

Integrated assessments contribute to decision-making processes by responding to decision makers' needs, combining diverse information to highlight trade-offs between options and using modelling to show alternative futures. Key global integrated assessment processes include the Millennium Ecosystem Assessment (MA), Intergovernmental Panel on Climate Change (IPCC), Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), the Global Oceans Assessment and The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD). Each of these assessments tackle different topics but all focus on assessing the links between humans and the environment and identifying response options.

Integrated environmental assessments as a tool have the ability to strengthen decision making by being inclusive fora for stakeholders to engage as well as bringing together experts from different disciplines. However, building consensus and understanding among stakeholders and the gathering and assessment of evidence can be time consuming and costly, usually taking several years.

Integrated modelling

Integrated models, sometimes called integrated assessment models, have been developed to help guide the understanding of complex and long-term issues. They can provide robust information regarding plausible futures, and help to understand impacts of drivers and the implications of different policy choices. Such models are qualitative or quantitative descriptions of key components of a system, and of the relationships between those components. Most commonly, models relate human activities as indirect and direct drivers to aspects of the natural environment. Originally in the 1980s integrated models were developed for climate change and pollution impacts, but more recently, multiple integrated models and scenarios have been developed that cover other impacts (such as IMAGE, GLOBIOM, InVEST, LandSHIFT and SRES (see overview in IPBES 2016b)). Together with scenarios (representations of possible futures for one or more components of a system), these models are usually embedded in assessments (see above) or decision-support processes to help inform policy and decision-making (IPBES 2016e). Integrated models provide a method and process for integrating multiple drivers and impacts using functional relationships. The relationships between Global Goals could potentially be assessed using integrated models and scenarios of related decisions and actions.

While integrated models provide helpful outputs, and are useful for communicating options, multiple challenges need to be considered when using models and scenarios. Models need to be sufficiently detailed to address a problem, yet simple enough to be applicable in assessments. As representations of reality, models can only incompletely consider relevant drivers; in fact, the uncertainties associated with models are often poorly evaluated and reported, leading to misconceptions (IPBES 2016e). Different policy and decision contexts will likely require different models and scenarios appropriate to the issue and spatial and temporal scales under consideration. To develop an integrated model relevant to addressing all Global Goals and their complex relationships, will likely require linking and harmonising models and scenarios across multiple domains, which is challenging (Cheung *et al.* 2016).

3 Conclusions and potential next steps

This report has summarised the central role of environment-human interactions in progress towards the Global Goals as an indivisible whole. It has also explored the more specific relevance of environment-human interactions to individual Goals, summarising recent advances in research, innovations and policies, and remaining knowledge gaps for each individual Goal. It further provides a range of perspectives on the relationships among the Goals and how a focus on environment-human interactions may affect this perspective. The report identifies 20 pairwise relationships among Goals where the role of environment-human interactions may be especially important.

The syntheses of research evidence, innovations and policies regarding environment-human interactions relevant to each Global Goal and the analysis of the relationships among Goals provide a basis for identifying priority areas for new research, innovation and policy. However, it is a starting point rather than a prioritisation in itself. The next steps that may help the Bellagio Group move towards identifying priority areas for the NERC, The Rockefeller Foundation, ESRC Towards a Sustainable Earth: Environment-human Systems and the UN Global Goals (TaSE) initiative to support include:

- Review the pairwise relationships between Global Goals that have been identified as being especially strongly influenced by environment-human interactions. Does the initial assessment seem appropriate? Have important relationships been missed? Are some relationships more or less influenced by environment-human interactions than this assessment suggests? Which of the relationships between Goals are primarily 'positive' or 'negative' (what is the balance between potential trade-offs and synergies?)? Are there clusters of relationships that would be better represented in another, more multi-dimensional, way?
- Link research evidence and knowledge gaps to the key relationships identified here (for instance, those in Box 2 or a modified subset). This could involve:
  - Considering the available evidence (in Part 1 of this report and expert knowledge), to assess confidence in the 'strength' of the different relationships.
  - Mapping the identified knowledge gaps (in Part 1 of the report and expert knowledge), to the individual relationships (as illustrated in Boxes 3 and 4), and examining the roles of recurring gaps.
- **Identify additional (previously unknown) research gaps.** This report is based on existing assessments and reviews. It has not identified knowledge gaps that have not been previously reported. However, the innovations required for transformational change needed to achieve the Goals may have large and, as yet, poorly understood impacts on environment-human interactions.
- **Map the landscape of networks and funding programmes to priority areas**. This report introduces a non-exhaustive list of past, current and future networks, and funding programmes. For potential priority areas, it may be helpful to identify relevant networks and funding programmes from this list (Section 5 in individual Goal chapters and Annex B) and add additional ones from the group's knowledge.

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5 Annexes

5.1 ANNEX A: UN GLOBAL GOALS FOR SUSTAINABLE DEVELOPMENT AND THEIR TARGETS

Goal 1. End poverty in all its forms everywhere

1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day

1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions

1.3 Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable

1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance

1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters

1.a Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation, in order to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programmes and policies to end poverty in all its dimensions

1.b Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions

Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture

2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons

2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment

2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed

2.a Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries

2.b Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round

2.c Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility

Goal 3. Ensure healthy lives and promote well-being for all at all ages

3.1 By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births
3.2 By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births
3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases
3.4 By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being
3.5 Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol
3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents
3.7 By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes
3.8 Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all
3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination
3.a Strengthen the implementation of the World Health Organization Framework Convention on Tobacco Control in all countries, as appropriate
3.b Support the research and development of vaccines and medicines for the communicable and non-communicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration on the TRIPS Agreement and Public Health, which affirms the right of developing countries to use to the full the provisions in the Agreement on Trade-Related Aspects of Intellectual Property Rights regarding flexibilities to protect public health, and, in particular, provide access to medicines for all
3.c Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States
3.d Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks

Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

4.1 By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes
4.2 By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education
4.3 By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university
4.4 By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship
4.5 By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations
4.6 By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy
4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development

4.a Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all
4.b By 2020, substantially expand globally the number of scholarships available to developing countries, in particular least developed countries, small island developing States and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries
4.c By 2030, substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small island developing States

Goal 5. Achieve gender equality and empower all women and girls

5.1 End all forms of discrimination against all women and girls everywhere
5.2 Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation
5.3 Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation
5.4 Recognize and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate
5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life
5.6 Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences
5.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws
5.b Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women
5.c Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels

Goal 6. Ensure availability and sustainable management of water and sanitation for all

6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
6.a By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies
6.b Support and strengthen the participation of local communities in improving water and sanitation management

Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all

7.1 By 2030, ensure universal access to affordable, reliable and modern energy services

7.2 By 2030, increase substantially the share of renewable energy in the global energy mix

7.3 By 2030, double the global rate of improvement in energy efficiency

7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology

7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support

Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries

8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors

8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services

8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead

8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value

8.6 By 2020, substantially reduce the proportion of youth not in employment, education or training

8.7 Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms

8.8 Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment

8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products

8.10 Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all

8.a Increase Aid for Trade support for developing countries, in particular least developed countries, including through the Enhanced Integrated Framework for Trade-Related Technical Assistance to Least Developed Countries

8.b By 2020, develop and operationalize a global strategy for youth employment and implement the Global Jobs Pact of the International Labour Organization

Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all

9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries

9.3 Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets

9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities
9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending
9.a Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States
9.b Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities
9.c Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020

Goal 10. Reduce inequality within and among countries

10.1 By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average
10.2 By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status
10.3 Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard
10.4 Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality
10.5 Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations
10.6 Ensure enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions in order to deliver more effective, credible, accountable and legitimate institutions
10.7 Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies
10.a Implement the principle of special and differential treatment for developing countries, in particular least developed countries, in accordance with World Trade Organization agreements
10.b Encourage official development assistance and financial flows, including foreign direct investment, to States where the need is greatest, in particular least developed countries, African countries, small island developing States and landlocked developing countries, in accordance with their national plans and programmes
10.c By 2030, reduce to less than 3 per cent the transaction costs of migrant remittances and eliminate remittance corridors with costs higher than 5 per cent

Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums
11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons
11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries
11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage
11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management

11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities
11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning
11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels
11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials

Goal 12. Ensure sustainable consumption and production patterns

12.1 Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries
12.2 By 2030, achieve the sustainable management and efficient use of natural resources
12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses
12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment
12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse
12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle
12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities
12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature
12.a Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production
12.b Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products
12.c Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities

Goal 13. Take urgent action to combat climate change and its impacts*

13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
13.2 Integrate climate change measures into national policies, strategies and planning
13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible
13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities

* *Acknowledging that the United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change.*

Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development

14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution

14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans

14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels

14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics

14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information

14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation

14.7 By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism

14.a Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries

14.b Provide access for small-scale artisanal fishers to marine resources and markets

14.c Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of The Future We Want

Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements

15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally

15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world

15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development

15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species

15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed

15.7 Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products

15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species

15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts

15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems
15.b Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation
15.c Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities

Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

16.1 Significantly reduce all forms of violence and related death rates everywhere
16.2 End abuse, exploitation, trafficking and all forms of violence against and torture of children
16.3 Promote the rule of law at the national and international levels and ensure equal access to justice for all
16.4 By 2030, significantly reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organized crime
16.5 Substantially reduce corruption and bribery in all their forms
16.6 Develop effective, accountable and transparent institutions at all levels
16.7 Ensure responsive, inclusive, participatory and representative decision-making at all levels
16.8 Broaden and strengthen the participation of developing countries in the institutions of global governance
16.9 By 2030, provide legal identity for all, including birth registration
16.10 Ensure public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements
16.a Strengthen relevant national institutions, including through international cooperation, for building capacity at all levels, in particular in developing countries, to prevent violence and combat terrorism and crime
16.b Promote and enforce non-discriminatory laws and policies for sustainable development

Goal 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

Finance

17.1 Strengthen domestic resource mobilization, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection
17.2 Developed countries to implement fully their official development assistance commitments, including the commitment by many developed countries to achieve the target of 0.7 per cent of ODA/GNI to developing countries and 0.15 to 0.20 per cent of ODA/GNI to least developed countries; ODA providers are encouraged to consider setting a target to provide at least 0.20 per cent of ODA/GNI to least developed countries
17.3 Mobilize additional financial resources for developing countries from multiple sources
17.4 Assist developing countries in attaining long-term debt sustainability through coordinated policies aimed at fostering debt financing, debt relief and debt restructuring, as appropriate, and address the external debt of highly indebted poor countries to reduce debt distress
17.5 Adopt and implement investment promotion regimes for least developed countries

Technology

17.6 Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism
17.7 Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed
17.8 Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology

Capacity-building

17.9 Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the sustainable development goals, including through North-South, South-South and triangular cooperation

Trade

17.10 Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the World Trade Organization, including through the conclusion of negotiations under its Doha Development Agenda

17.11 Significantly increase the exports of developing countries, in particular with a view to doubling the least developed countries' share of global exports by 2020

17.12 Realize timely implementation of duty-free and quota-free market access on a lasting basis for all least developed countries, consistent with World Trade Organization decisions, including by ensuring that preferential rules of origin applicable to imports from least developed countries are transparent and simple, and contribute to facilitating market access

Systemic issues

Policy and institutional coherence

17.13 Enhance global macroeconomic stability, including through policy coordination and policy coherence

17.14 Enhance policy coherence for sustainable development

17.15 Respect each country's policy space and leadership to establish and implement policies for poverty eradication and sustainable development

Multi-stakeholder partnerships

17.16 Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the sustainable development goals in all countries, in particular developing countries

17.17 Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships

Data, monitoring and accountability

17.18 By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts

17.19 By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and support statistical capacity-building in developing countries

5.2 ANNEX B: DETAILS OF LARGE-SCALE NETWORKS AND FUNDING PROGRAMMES RELATED TO THE GLOBAL GOALS WITHIN THE CONTEXT OF ENVIRONMENT-HUMAN RELATIONSHIPS.

The list is organised by Global Goal, with cross-cutting networks and funding listed under Global Goal 17 at the end of the Annex. The list provides some examples for each Global Goal, however, it is not exhaustive. Information is provided on each of the networks based on the readily available information from the networks and funders web-pages and reports. It was not possible to obtain consistent information on all networks and funders, however, where possible the information touches on the aims of the network or funding, and or the funding available.

5.2.1 Global Goal 1

UNDP-UNEP Poverty-Environment Initiative (PEI) is a global programme that supports country-led efforts to put pro-poor, pro-environment objectives into the heart of government by mainstreaming poverty-environment objectives into national development and sub-national development planning, from policymaking to budgeting, implementation and monitoring. With both financial and technical support, PEI assists government decision-makers and a wide range of other stakeholders to manage the environment in a way that improves livelihoods and leads to sustainable growth. PEI was formally launched in 2005 and significantly scaled-up in 2007 by the UNEP Governing Council. It is supporting programmes in 22 countries across all its regions. Phase II (2013–2017) saw the implementation of new poverty-environment mainstreaming projects in an additional five countries. The Initiative is currently funded by the Governments of Norway, Spain, Sweden, the United Kingdom and the European Union.

Poverty Environment Network (PEN) is an international research project and network. PEN was a six-year project (2004-2010), and now constitutes the largest and most comprehensive global analysis of tropical forests and poverty. The core of PEN is the tropics-wide collection of uniform socio-economic and environmental data at household and village levels by about 30 PEN partners (mainly PhD students), which generated a global database with some 5-6,000 households and 200-250 villages from more than 20 countries. The study aimed to put forests more firmly onto the poverty agenda by informing and influencing mainstream forest policy formulation and implementation. PEN was coordinated by CIFOR, and received a major grant from DFID (UK) to support the post-data collection phase (2007-2010) of data analysis, synthesis and dissemination of results. Several PEN partners received fieldwork support from the International Foundation of Science (IFS). Other major donors included the ESRC (UK), DANIDA, USAID and BASIS.

The Poverty-Environment Partnership (PEP) was established after the 2002 World Summit on Sustainable Development as an informal network of like-minded organisations committed to ending extreme poverty while sustaining the environment. PEP focused on the achievement of the Millennium Development Goals, playing a significant role in building a new evidence-based narrative on how the environment matters to the livelihoods and well-being of poor and vulnerable groups, and on the need for integrated approaches to poverty reduction and environmental management. With the agreement of the Sustainable Development Goals in 2015, the PEP committed to putting the goals into action at the country level with poverty reduction, climate resilience and environmental sustainability at their heart.

Poverty Environment Net is the leading index of poverty-environment knowledge and resources, dedicated to sharing information and lessons gained from the beneficial relationship between environmental management and poverty reduction. The website has been established through a technical assistance of the Asian Development Bank (ADB), co-financed by ADB and the Governments of Norway and Sweden, and managed by ADB's Environment Community of Practice.

Poverty and Conservation Learning Group (PCLG) is an international network of more than 100 conservation and development organisations that promotes learning on the linkages between biodiversity conservation and poverty reduction, in order to improve policy and practice. It is hosted by the International Institute for Environment and Development (IIED). One of the key activities of the PCLG Secretariat is to collect information on poverty-conservation issues and activities, and collate it for members on the PCLG website. As well as providing a comprehensive listings of events, conservation organisations and initiatives, the PCLG maintains a searchable bibliographic database currently containing over 1800 titles on the links between conservation and poverty. The PCLG also publishes its own series of discussion papers – usually outputs of research that we have been involved in – and convenes or supports learning events that tackle key issues relevant to PCLG members.

The Partnership for Environment and Disaster Risk Reduction (PEDRR), formally established in 2008, is a global alliance of UN agencies, NGOs and specialist institutes. It is a global thematic platform of the International Strategy for Disaster Reduction (ISDR) and seeks to promote and scale-up implementation of ecosystem-based disaster risk reduction and ensure it is mainstreamed in development planning at global, national and local levels, in line with the Sendai Framework for Disaster Risk Reduction. It provides technical and science-based expertise and applies best practices in ecosystems-based DRR approaches. PEDRR is guided by its vision of: "Resilient communities as a result of improved ecosystem management for disaster risk reduction (DRR) and climate change adaptation (CCA)". Its objective is to pool expertise and advocate for policy change and best practice in ecosystem management for DRR and CCA, based on science and practitioners' experiences. The PEDRR Secretariat is hosted at the Post-Conflict and Disaster Management Branch (PCDMB) of the United Nations Environment Program in Geneva, Switzerland. The Secretariat is supported by UNEP/PCDMB and a rotating pool of interns, who are involved in PEDRR's social media, website, weekly newsletter, and other communication assignments.

The International Strategy for Disaster Reduction (ISDR), established in 1999, is a system of partnerships. These partnerships are composed of a broad range of actors. The overall objective of the ISDR Partnership is to generate and support a global disaster risk reduction movement to reduce risk to disasters. The UN General Assembly, through its Second Committee, remains the principal decision-making body for intergovernmental governance of the ISDR System

United Nations Office for Disaster Risk Reduction (UNISDR) was established in 1999 as a dedicated secretariat to facilitate the implementation of the International Strategy for Disaster Reduction (ISDR). It is mandated by the United Nations General Assembly resolution (56/195), to serve as the focal point in the United Nations system for the coordination of disaster reduction and to ensure synergies among the disaster reduction activities of the United Nations system and regional organizations and activities in socio-economic and humanitarian fields. It is an organisational unit of the UN Secretariat and is led by the UN Special Representative of the Secretary-General for Disaster Risk Reduction (SRSG). UNISDR defines itself through its multi-stakeholder coordination approach based on the relationships it has developed with national and local governments, intergovernmental organizations and civil society, including the private sector, and by its mode of operating through a network of global partners.

5.2.2 Global Goal 2

UN World Food Programme (WFP), founded in 1961, pursues a vision of the world in which every man, woman and child has access at all times to the food needed for an active and healthy life. They work towards that vision with its sister UN agencies, the Food and Agriculture Organization (FAO) and the International Fund for Agricultural Development (IFAD), as well as other government, UN and NGO partners. On average, WFP reaches more than 80 million people with food assistance in 82 countries each year. 11,367 people work for the organization, most of them in remote areas, directly serving the hungry poor. In 2015 received a total contribution of approximately USD 5 billion.

Food and Agriculture Organization of the United Nations (FAO) of the United Nations is the main global network on food, it has 194 Member States. It aims to achieve food security for all and to make sure people have regular access to enough high-quality food to lead active, healthy lives. FAO's three main goals are: the eradication of hunger, food insecurity and malnutrition; the elimination of poverty and the driving forward of economic and social progress for all; and, the sustainable management and utilization of natural resources, including land, water, air, climate and genetic resources for the benefit of present and future generations. FAO had a budget of USD 2.6 billion for 2016-17. The majority (61 per cent) of its funding is raised through voluntary support; the remainder from contributions by member countries. The FAO engages with financing initiatives such as the Green Climate Fund, and the Global Environment Facility; the FAO also has projects including: Climate Smart Agriculture, Commission on Genetic Resources for Food and Agriculture, Energy-Smart Food for People and Climate, World Soil Charter, Global Soil Partnership, Global Agenda for Sustainable Livestock and the Farmers Field School (FFS) in Asia and Africa.

Global Partnership on Nutrient Management (GPNM) is a global platform to steer dialogues and actions to promote effective nutrient management. The GPNM is a response to this 'nutrient challenge' – how to reduce the amount of excess nutrients in the global environment consistent with global development. It provides a platform for governments, UN agencies, scientists and the private sector to forge a common agenda, mainstreaming best practices and integrated assessments, so that policy making and investments are effectively 'nutrient proofed'. The GPNM also provide a space where countries and

other stakeholders can forge more co-operative work across the variety of international & regional fora and agencies dealing with nutrients, including the importance of assessment work.

Global Panel on Agriculture and Food Systems for Nutrition is an independent group of experts committed to tackling global challenges in food and nutrition security. Since August 2013, the London International Development Centre (LIDC) has acted as the Secretariat for the Global Panel. LIDC facilitates interdisciplinary research and training to tackle complex problems in international development. The Global Panel is jointly funded by UKaid and the Bill and Melinda Gates Foundation.

The Economics of Ecosystems and Biodiversity (TEEB) Agriculture and Food study, led by the UNEP TEEB Office, brings together a network of scientists, economists, policymakers, business leaders and farmers' organisations to undertake a comprehensive economic evaluation of agricultural systems, practices, products, or policy scenarios against a comprehensive range of impacts and dependencies across the value chain.

Global Environmental Change and Food Systems (GECAFS) was a 10-year (2001-2011) comprehensive programme by IGBP, IHDP and WCRP of international, interdisciplinary research focused on understanding the links between food security and global environmental change.

PROteINSECT is an EU research project that evaluates the use of insects as a sustainable source of protein. PROteINSECT focused on five key areas in order to evaluate insects as a novel source of protein for animal feed and to ensure that methodologies are sustainable and economically viable. This initiative is co-financed by the EC under FP7.

Global Environment Facility (GEF) launched a new programme entitled Fostering Sustainability and Resilience for Food Security in Sub-Saharan Africa, investing USD 900 million over five years from 2015. The GEF also works on issues to address the water, food, energy and ecosystem nexus. An example of how this funding is employed includes the Sahel and West Africa Programme (SAWAP) on land management, productivity and climate resilience.

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) addresses the increasing challenge of global warming and declining food security on agricultural practices, policies and measures through a strategic collaboration between CGIAR and Future Earth. Led by the International Center for Tropical Agriculture (CIAT), CCAFS is a collaboration among all 15 CGIAR research centers and coordinates with the other CGIAR research programs. CCAFS brings together some of the world's best researchers in agricultural science, climate science, environmental and social sciences to identify and address the most important interactions, synergies and trade-offs between climate change and agriculture. The program is carried out with funding support from governments and aid agencies, both through the CGIAR Fund and bilaterally. Current donors include: CGIAR Fund Donors, Australia (ACIAR), Ireland (Irish Aid), Netherlands (Ministry of Foreign Affairs), New Zealand, New Zealand, Thailand (through the Department of Agriculture), the UK Government (UK Aid), USA (USAID), and the European Union (EU). The Program is carried out with technical support from the International Fund for Agricultural Development (IFAD).

Other relevant international partnerships include: **Commission on Genetic Resources for Food and Agriculture**; **CSA Alliance**; **Energy-Smart Food for People and Climate (ESF)**; **Global Agenda for Sustainable Livestock**; **Global Soil Partnership (GSP)**; **World Soil Charter**; **Future Earth Knowledge network – Water-Energy-Food Nexus**.

5.2.3 Global Goal 3

The World Health Organisation is the directing and coordinating authority on international health within the United Nations system. It works in 150 countries to the help support the highest attainable level of health for all people, and to combat diseases. It provides leadership on matters critical to health and engages in partnerships where joint action is needed; shapes the research agenda and stimulates the generation, translation and dissemination of valuable knowledge; sets norms and standards and promotes and monitors their implementation; articulates ethical and evidence-based policy options; provides technical support, catalyses change, and builds sustainable institutional capacity; and monitors the health situation and assesses health trends. WHO Health and Environment Linkages (HELI) network encourages countries to address linkages as integral to economic development, and supports the evaluation of ecosystem services for health. A number of new funding initiatives have been established in recognition of the critical need to address data, for example, the World Bank and WHO, with input from several agencies and countries, have developed a *Global Civil Registration and Vital Statistics Scaling Up Investment Plan*.

Cochrane is a global independent network of researchers, professionals, patients, carers, and people interested in health. Cochrane contributors – 37,000 from more than 130 countries – work together to produce credible, accessible health information that is free from commercial sponsorship and other conflicts of interest. Many of its contributors are world leaders in their fields – medicine, health policy, research methodology, or consumer advocacy – and its groups are situated in some of the world's most respected academic and medical institutions.

The Future Earth Health Knowledge-Action Network responds to a call by the Rockfeller Foundation-Lancet Commission on planetary health in 2015 to develop the avenue of research on planetary health. This network brings health, social and natural scientists together with policy experts, and members of the private and public sectors to integrate the understanding of the interactions between the global environment and human health. Together, Future Earth oneHEALTH, ICSU programme on Urban Health and Well-being, The Rockfeller Foundation-Lancet Commission on Planetary Health, the World Health Organisation, and the United Nations University's International Institute for Global Health aim to work collaboratively on these efforts.

Health and Environment Alliance (HEAL) is a leading not-for-profit organisation how the environment affects health in the European Union (EU). With the support of more than 70 member organisations, HEAL brings independent expertise and evidence from the health community to different decision-making processes. Its broad alliance represents health professionals, not-for-profit health insurers, doctors, nurses, cancer and asthma groups, citizens, women's groups, youth groups, environmental NGOs, scientists and public health institutes. Members include international and Europe-wide organisations as well as national and local groups in 25 countries both within EU member states and the wider European region, as defined by the World Health Organisation (WHO).

The Global Civil Registration and Vital Statistics (CRVS) Scaling Up Investment Plan has been developed by the World Bank and the World Health Organization, with input from several agencies and countries to support CRVS. The scaling up investment plan provides a coherent, global effort to ensure all countries have a sustainable civil registration and vital statistics integrated across government and serving the needs of public and private sectors and all citizens of a country.

Bill and Melinda Gates Foundation is one of the largest private foundation in the world, founded by Bill and Melinda Gates. The primary aims of the foundation are, globally, to enhance healthcare and reduce extreme poverty, and in America, to expand educational opportunities and access to information technology. Its recent work includes supporting the WHO to estimate the burden of dengue in selected countries.

Bloomberg Philanthropies is a foundation that works to ensure better, longer lives for the greatest number of people. It focus on five key areas, including public health and the environment. Bloomberg Philanthropies funds health work including, Data for Health, a USD 100 million initiative that will enable 20 low- and middle-income countries (LMICs) to vastly improve public health data collection and its use.

5.2.4 Global Goal 4

Networks

The UNESCO-led Decade of Education for Sustainable Development (DESD) and its follow-on initiative, the **Global Action Programme (GAP)**, have acted as the major platforms for advocating sustainable development to be included in formal and informal education. The GAP on Education for Sustainable Development (ESD) seeks to generate and scale-up concrete actions in ESD and is intended to make a substantial contribution to the post-2015 agenda. It deploys a two-fold approach to multiply and to scale up ESD action: (1) integrating sustainable development into education; and (2) integrating education into sustainable development. Based on the lessons learned from the DESD, the GAP has identified five priority areas of work: (1) advancing policy; (2) transforming learning and training environments; (3) building capacities of educators and trainers; (4) empowering and mobilizing youth; and (5) accelerating sustainable solutions at local level. It has established partner networks, currently including 87 members, around each priority to drive implementation of the GAP on ESD and to serve as a global community of practice. UNESCO selects the members of the Partner Networks based on the GAP Launch Commitments received from stakeholders.

UNEP's Environmental Education and Training Unit (EETU), works on the links between the environment and education and also serves as a focal point for implementation of the GAP. EETU's programmes, projects, initiatives and activities are organized around three pillars, namely, education, training and networking with specific focus on higher education, through the **Global Universities**

Partnership on Environment and Sustainability (GUPES). The EETU is responsible for the implementation of Environmental Education and Training activities in UNEP. This is done in close collaboration with other relevant Divisions, Branches and Units in UNEP, as well as with other partners – mainly institutions of higher learning. Other partners include other UN agencies, governments, national and regional environmental education and training centres, local and international non-governmental organizations and the private sector.

UN University is a global think tank and postgraduate teaching organization headquartered in Japan. The mission of the UN University is to contribute, through collaborative research and education, to efforts to resolve the pressing global problems of human survival, development and welfare that are the concern of the United Nations, its Peoples and Member States. In carrying out this mission, the UN University works with leading universities and research institutes in UN Member States, functioning as a bridge between the international academic community and the United Nations system.

The World Wide Fund for Nature (WWF) network currently conducts one of the largest, most diverse and widespread programmes of environmental education led by an international organisation. Environmental education has been a part of WWF's work since the organisation's inception. Education programmes initiated by WWF, including school and outreach programmes, community learning and developing curricula, aim to empower and motivate young people, partners and local communities, to solve the challenges facing the environment.

Funding

Overall, between 2011 and 2013, official development assistance for educational scholarships (not limited to ESD) amounted to around USD 1.1 billion annually. It totalled USD 1.2 billion in 2014, with Australia, France and Japan being the largest contributors.

5.2.5 Global Goal 5

Networks

UN Women, established in 2010, merges and builds on the important work of four previously distinct parts of the UN system, which focused exclusively on gender equality and women's empowerment. The main roles of UN Women are: (1) to support inter-governmental bodies, such as the Commission on the Status of Women, in their formulation of policies, global standards and norms; (2) to help Member States to implement these standards, standing ready to provide suitable technical and financial support to those countries that request it, and to forge effective partnerships with civil society: (3) to lead and coordinate the UN system's work on gender equality as well as promote accountability, including through regular monitoring of system-wide progress. UN Women, amongst other things, on sustainable development and climate change, and gender lies within one of UNEP's priority areas of work.

UNEP's Gender and the Environment work constitutes a key priority. Its gender mainstreaming work broadly takes place at two levels: the organisational and the programme levels. From a programme perspective, UNEP ensures all its projects reflect the different needs of women and men. Whenever possible, it also seeks to promote a strong gender perspective in environmental policies at the national, regional and international levels. From an organisational perspective, UNEP is focusing gender mainstreaming on internal policies and processes. Within the UN system, it partners with **UN Women, UNDP, Inter-Agency Network on Women and Gender Equality (IANWGE)**, and the **Global Environment Facility (GEF)**. The Programme also partners with international organisations such as **International Network on Gender and Energy (ENERGIA), Women's Earth and Climate Action Network (WECAN), Women in Europe for a Common Future (WECF)** and **IUCN**; as well as alliances like the **Global Gender and Climate Alliance (GGCA)** and the **Gender and Water Alliance (GWA)**.

Women's Environment and Development Organization (WEDO), a global women's advocacy organization, headquartered in New York. It is a facilitator and convener, partnering with hundreds of women's groups around the world, to demand a just and sustainable future. WEDO is also a technical advisor, to Governments and UN agencies on how to implement intersectional and transformative approaches to sustainable development in policy and practice. It considers itself a feminist movement calling for a peaceful and healthy planet.

IUCN's Global Gender Office (GGO) serves and supports IUCN members, offices, commissions and networks, as well as a wide range of programming with member and non-member partners. It contributes towards IUCN's vision and mission by providing innovative approaches, technical support, policy development and capacity building to a wide range of partners, ensuring gender equality is central to sustainable global environmental solutions. The GGO also hosts the **Environment and Gender**

Information (EGI) platform, which aims to close information gaps at the nexus of gender equality and environmental sustainability by providing global data on gender and environment. Originally launched in its 2013 pilot phase as a composite index, the EGI has evolved into a source for new knowledge creation and dissemination – and for revealing progress and challenges in meeting commitments to women's empowerment and gender equality in environmental spheres.

UNESCO's World Water Assessment Programme (WWAP) launched a project in 2014 to develop and test sex-disaggregated indicators for the collection of global water, which involved developing a methodology and toolkit for almost 50 high-priority gender and water indicators. Furthermore, the World Bank, FAO and WHO have all launched major efforts to collect gender-disaggregated data, some of it environment-related. FAO's Gender and Land Rights Database (GLRD), for example, was launched in 2010 to highlight the major political, legal and cultural factors that influence realisation of women's land rights throughout the world.

Funding

Current donors taking a particular interest in funding gender-environment initiatives include the Swedish government, who are supporting UNEP on gender integration, as well as the Dutch and Finnish governments, who fund gender-related projects as part of their work on addressing inequalities.

5.2.6 Global Goal 6

Networks

UN-Water Global Analysis and Assessment of Sanitation and Drinking-water (GLAAS) is a UN-Water initiative implemented by the World Health Organization (WHO). It aims to provide global scale analyses to inform policy.

United Nations Children's Fund's (UNICEF) Water, Sanitation and Hygiene Programme (WaSH) works in over 100 countries to improve water and sanitation.

Joint Monitoring Programme (JMP) for Water Supply and Sanitation (WHO and UNICEF) aims to accelerate universal access to safe water and sanitation by 2025, and to be a source of data on these topics world-wide for use by governments etc.

The United Nations Environment Programme (UNEP) has a number of initiatives relating to water issues such as the International Environmental Technology Centre (IETC), the Global Wastewater Initiative, the Global Partnership on Marine Litter (GPML), and the Transboundary Water Assessment Programme (TWAP) - GEF.

The Food and Agriculture Organization of the United Nations (FAO) has a Forest and Water Programme that integrates forest and water science, with policy and practice, and actively investigates the interactions between forests and water.

The United Nations Educational, Scientific and Cultural Organization (UNESCO)-International Hydrological Programme (IHP), and the **Institute for Water Education (IHE)**. IHP is the only intergovernmental programme of the UN system devoted to water research, water resources management, and education and capacity building. Since its inception in 1975, IHP has evolved from an internationally coordinated hydrological research programme into an encompassing, holistic programme to facilitate education and capacity building, and enhance water resources management and governance. IHP facilitates an interdisciplinary and integrated approach to watershed and aquifer management, which incorporates the social dimension of water resources, and promotes and develops international research in hydrological and freshwater sciences. IHP is entering its eighth phase to be implemented during the period 2014-2021.

The United Nations Educational, Scientific and Cultural Organization (UNESCO)-Institute for Water Education (IHE) is the largest international graduate water education facility in the world and is based in Delft, the Netherlands. The Institute confers fully accredited MSc degrees, and PhD degrees in collaboration with partner universities. UNESCO-IHE carries out educational, research and capacity development activities that complement and reinforce each other in the broad fields of water engineering, water management, environment, sanitation, and governance.

The Future Earth Knowledge Network has an initiative focussed on the Water-Energy-Food Nexus). This is a collaborative initiative between Future Earth, the Future Earth Cluster Activity on Sustainability for water, energy and food through integrated water information and improved governance, and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Water Footprint Network (WFN) was founded in 2008 to solve the world's water crises by advancing fair and smart water use. WFN's mission is to provide science-based, practical solutions and strategic insights that empower companies, governments, individuals and small-scale producers to transform the way we use and share fresh water within earth's limits.

WaterAid was set up in 1981 as a response to the UN International Drinking Water & Sanitation decade (1981-1990). The organisation was first established by the UK water industry as a charitable trust at their main office premises in London. As of 2013, WaterAid had fundraising offices located in Australia, Japan, Sweden, the United Kingdom and the United States while working in 27 countries worldwide.

Funding

Aid commitments for water and sanitation to all sectors from donors reporting to the Organisation for Economic Co-operation and Development – Common Reporting Standards (OECD-CRS) increased from USD 8 billion in 2010, to USD 11 billion in 2012 – a 30 per cent increase (UN-WATER and WHO, 2014). Data suggests that national government budgets and expenditures for water, sanitation and hygiene are also increasing but there remains a huge financing gap between budget and plans, with 8 per cent of countries indicating insufficient financing for the sector (UN-WATER and WHO, 2014). Reported government-coordinated expenditure (from taxes and transfers) on sanitation and drinking water ranged from less than 0.01 per cent to 1.78 per cent of GDP. In the GLAAS 2014 country survey, of the 12 major external support agencies, funding included USD 80 million from the Bill and Melinda Gates Foundation, SEK 410 million from Sweden, and CHF 150 million from Switzerland (UN-WATER and WHO, 2014).

5.2.7 Global Goal 7

The International Energy Agency (IEA) was established in 1974 with 29 member states. It focuses on four main work areas: energy security; economic development; environmental awareness; and global engagement. In 2014, the estimated total public energy research, development and demonstration spending by IEA member countries was approx. USD 17 billion (IEA 2015b).

The International Atomic Energy Agency (IAEA) is an independent entity formed in 1957 to promote the peaceful use of nuclear energy. The IAEA has 168 member states and its budget in 2016 was approx. USD 400 million.

The International Renewable Energy Agency (IRENA) was founded in 2009 with 75 states as signatory to IRENA's statute (now 143 with 30 states in various stages of accession). IRENA has a core budget of USD 43 million over its 2016-2017 work programme.

The Integrated Solutions for Water, energy and Land Project was launched in 2015 as a collaboration between the International Institute for Applied Systems Analysis (IIASA), the Global Environment Facility (GEF) and the United Nations Industrial Development Organization (UNIDO). It aims to identify integrated solutions to energy, water, food, and ecosystem security in selected regions of the world – regions faced by multiple energy and land use challenges, and rapid demographic, economic changes, and hardest hit by increasing climate variability and change.

The International Commission on Large Dams (ICOLD) is a non-governmental organisation that was founded in 1928 and has National Committees from more than 90 countries with approximately 10,000 individual members.

International Convention for the Prevention of Pollution from Ships, commonly referred to as MARPOL, is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. The Convention includes regulations aimed at preventing and minimizing pollution from ships – both accidental pollution and that from routine operations – and currently includes six technical Annexes. Special Areas with strict controls on operational discharges are included in most Annexes.

Marine Environment Protection Committee (MEPC) is an international agreement to reduce the sulfur content of fuel oil.

Marine Renewable Energy Research Programme was a four year collaborative programme with a budget of GBP 2.4 million funded by NERC and the Department for Environment, Food & Rural Affairs (Defra). The overall aim of the research programme was to understand the environmental benefits and risks of up-scaling marine renewable energy schemes on the quality of marine bioresources (including biodiversity) and biophysical dynamics of open coasts. The programme also aimed to make a significant contribution to the Living With Environmental Change programme.

5.2.8 Global Goal 8

The Global Green Growth Institute (GGGI) is an international organization established in 2012, at the Rio+20 United Nations Conference on Sustainable Development. Founded to support green economic growth that simultaneously addresses poverty reduction, job creation, social inclusion, and environmental sustainability, GGGI works across four priority areas considered to be essential to transforming national economies, including energy, water, land-use, and green cities. In 2015, GGGI had a total operating income of USD 48,744,398 and expenditures of USD 31,075,737 and total reserves of USD 33,792,146.

UN Partnership for Action on a Green Economy (UN-PAGE). A joint initiative between UNIDO, UNEP, UNDP, ILO and UNITAR that will provide a 'suite of green economy services' to governments to help them undergo the transition to a green economy. They represent a mechanism to coordinate UN action around the SDGs, particularly SDG 8. PAGE funding contributions and commitments currently stand at USD 26,106,039.

Green Growth Knowledge Platform (GGKP). Established by the Global Green Growth Institute, OECD, UNEP and the World Bank. The platform identifies and addresses major knowledge gaps in green growth theory and practice. Established in 2012, the group now includes a large group of Knowledge Partners. The GGKP has to 2015 been funded to the amount USD 6,077,260. Expenditures of USD 4,614,040 went on the general work areas of knowledge generation (24.5 per cent of expenditure), Knowledge management (21.2 per cent), and Knowledge sharing (54.3 per cent)

Green Economy Coalition (GEC) is a divers set of organisations including NGOs, research institutions, UN organisations, business groups and trade unions. The overall aim is to accelerate a transition to a green economy. GEC activities include: coordinating multi-stakeholder national dialogues; researching and identifying policies necessary for the transition; representing stakeholders in national and international processes; enagaging new audiences; lobbying key decision makers.

A number of networks exist to support countries, organisations and individuals to access case studies, lessons learnt, standards and other resources on nature based tourism. These include the International Ecotourism Society, World Tourism Organisation, and Pro-poor Tourism.

Future Earth Finance and Economics Knowledge-Action Network will bring broad communities of researchers, practitioners and end-users together to explore how to align global financial and economic systems, business models, and consumption and production patterns towards sustainability both conceptually and in practice. This Knowledge-Action Network considers the financial and economic system as part of a larger complex socio-ecological system and its goal is to stimulate co-design processes that lead to new research proposals, engagement activities and the emergence of research-based solutions. This will be done via mapping and scoping processes together using the Future Earth Open Network as well as convening leading thinkers and the growing community of innovators in the area of sustainable finance, business models and economic systems.

The Climate and Development Knowledge Network (CDKN) supports decision-makers in designing and delivering climate compatible development by combining research, advisory services and knowledge management in support of locally owned and managed policy processes. It works in partnership with decision-makers in the public, private and non-governmental sectors nationally, regionally and globally. It is managed by an alliance of organisations led by PricewaterhouseCoopers LLP (PwC), and including Fundación Futuro Latinoamericano, LEAD International, LEAD Pakistan, the Overseas Development Institute, and SouthSouthNorth. CDKN received funding contributions of around GBP 88 million in 2015.

The Inclusive Wealth Project is a group of researchers and economists who want to redefine what nations regard as wealth: as the potential to create and sustain humanity's well-being. It aims to provide countries with a realistic understanding of their wealth, and their prospects for long-term sustainability. It is a joint initiative of the United Nations University International Human Dimensions Programme (UNU-IHDP) and the United Nations Environment Programme (UNEP) in collaboration with the United Nations Educational, Scientific and Cultural Organization (UNESCO).

The Natural Capital Project is a partnership of two world-class academic institutions, Stanford University and the University of Minnesota, with The Nature Conservancy and World Wildlife Fund.

The Natural Capital Coalition is a unique global multi-stakeholder collaboration that brings together leading global initiatives and organizations to harmonize approaches to natural capital. The Coalition is made up of organizations from research, science, academia, business, advisory, membership,

accountancy, reporting, standard setting, finance, investment, policy, government, conservation and civil society. These organizations have united under a common vision of a world where business conserves and enhances natural capital. The Coalition's strength comes from this diversity, and from a shared belief that more can achieved together than alone.

5.2.9 Global Goal 9

UNEP (2012) – The Eco-Innovation Project. In partnership with the European Commission this four year project (finishing in 2016) aims to promote resource efficiency and eco-innovation through engaging SMEs in an eco-innovation process by facilitating policy and technical conditions enabling systemic innovation and capacity building. 175 stakeholders in agri-food, metals and chemicals industries.

UNEP - Global Clean Ports Project. In collaboration with the United States, Canada and the International Council on Clean Transportation (ICCT). Funded by the Climate and Clean Air Coalition to Reduce Short Lived Climate Pollutants (CCAC). This aims to reduce emissions from ports and maritime sources.

UNIDO – Energy efficiency programmes. In 2015 UNIDO reported that it's energy efficiency projects were funded to a total of USD 52.2 million in grant funding with an additional 574 million in co-funding. Projects in partnership with the Global Environment Fund (GEF) aim to promote energy efficiency through policy, economic, technical and social aspects to disseminate and support Best practice and technologies for industrial energy management and the adoption of low carbon technologies.

The Green Grid (TGG) is a global consortium of companies, government agencies, and educational institutions dedicated to advancing energy efficiency in data centers and business computing ecosystems.

International Civil Aviation Organization (ICAO) has a Council Committee on Aviation Environmental Protection (CAEP). Currently developing a global Market-based measures scheme (extension of EU ETS to global Aviation entering EU airspace currently still delayed in anticipation of global mechanism). Also hosts Global Framework for Aviation Alternative Fuels which undertake a variety of global activities and projects.

5.2.10 Global Goal 10

Future Earth Knowledge Network on Sustainable Development Goals to bring together knowledge and processes of the Future Earth community to make efforts to implement actions to achieve the SDGs

Environmental Justice Atlas is an initiative which documents and catalogues social conflict around environmental issues, and is coordinated at the Autonomous University of Barcelona and was supported by the European Commission between 2011 and 2015.

World Inequality Database on Education (WIDE), set up by UNESCO, brings together data from Demographic and Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS), national household surveys and learning achievement surveys from over 160 countries to enable users to compare education outcomes between countries, and between groups within countries, according to factors that are associated with inequality, including wealth, gender, ethnicity and location.

International Treaty on Plant Genetic Resources for Food and Agriculture established in 2004, established a multilateral system of ABS (Access and Benefit Sharing) that facilitates access to plant genetic resources of the most important crops for food security, on the basis of a Standard Material Transfer Agreement (SMTA).

Environmental Justice Foundation (EJF) is a UK-based non-profit organisation working internationally to protect the environment and defend human rights. EJF was founded in 2000 and now has an international team based in the UK, Spain, Germany, Cote d'Ivoire, Ghana, Liberia and Sierra Leone. EJF's work aims to be direct and effective, from investigations, field projects and community partnerships to policy briefings and reports, campaign films and international advocacy that reach the highest levels of policy making in government, business and amongst the public.

5.2.11 Global Goal 11

European Initiative Smart Cities and Communities, of the European Union which provides funds to European regions for boosting smart sustainable solutions for cities.

The Partnership for Sustainable Communities, is a collaboration between three U.S. federal agencies to help improve access to affordable housing, create more transportation options and lower Americans' transportation costs while protecting the environment in communities nationwide.

The Multilateral Development Bank Working Group on Sustainable Transport, eight International Development Banks agreed to provide more than USD 175 billion of loans and grants for transport in developing countries during the period 2012-2022.

The Water for Asian Cities programme is a collaborative initiative of UN-HABITAT, the Asian Development Bank and governments of Asia. The programme invested USD 1.5 billion in water and sanitation in the Asian region between 2003 and 2011.

The Major International City Networks and Initiatives on Climate Change was formed in 2013. This is an umbrella group for many ongoing partnerships and initiatives: ICLEI-Local Governments for Sustainability, **the Large Cities Climate Leadership Group** (also known as the C40), **the Clinton Climate Initiative**, **the World Mayors Council for Climate Change**, **United Cities and Local Governments, the Climate Alliance, the Asian Cities Climate Change Resilience Network, the Covenant of Mayors.**

Future Earth Cities Knowledge-Action Network is a collaborative initiative building on contributions from the Future Earth Community but also aiming for broader engagements from research and stakeholder communities globally. Its focus is to: build a global research platform and engagement network on urbanization and sustainable cities; become a key source of knowledge from integrative, interdisciplinary and trans-disciplinary research across natural and social sciences, engineering and humanities, for practitioners, policy and decision-makers; and contribute to the transition and transformation towards sustainable urban futures where cities are more liveable, equitable and resilient through co-developed and solutions-oriented research.

5.2.12 Global Goal 12

The 10-year framework of programmes on sustainable consumption and production patterns (10YFP) is a global framework of action to enhance international cooperation to accelerate the shift towards sustainable consumption and production in both developed and developing countries. The 10YFP aims at developing, replicating and scaling up SCP and resource efficiency initiatives, at national and regional levels, decoupling environmental degradation and resource use from economic growth, and thus increasing the net contribution of economic activities to poverty eradication and social development. The framework supports capacity building, and facilitates access to technical and financial assistance for developing countries. The framework is meant to encourage innovation and cooperation among all stakeholders. Interested actors from all countries can be involved in the implementation of the 10YFP activities: governments, private sector, civil society, researchers, UN agencies, financial institutions, and other major groups. UNEP provides the Secretariat to the 10YFP and its associated activities.

The Global SCP Clearinghouse has been created to support the aims of the 10YFP. It aims at bringing together and expanding the SCP community worldwide, collecting, disseminating and sharing initiatives, policies, tools and best practices, the latest news and events on SCP as well as cooperation opportunities in order to trigger more innovation and cooperation towards SCP implementation around the world.

The Global Research Forum on Sustainable Production and Consumption (GRF-SPaC) was created in 2012 by and for the community of researchers and practitioners engaged in research on the worldwide transition to sustainable production and consumption systems. GRF-SPC strives to develop and strengthen methods of fundamental and applied research to achieve a deeper understanding of the possibilities and barriers to systemic change. Its ultimate goal is to enhance development and adoption of production and consumption policies, practices and systems which meet basic needs –especially of the poor and vulnerable- and provide prosperity, while conserving natural resources and protecting the environment.

5.2.13 Global Goal 13

Networks

The Climate Action Network (CAN) is a worldwide network of over 1100 Non-Governmental Organizations (NGOs) in more than 120 countries, working to promote government and individual action to limit human-induced climate change to ecologically sustainable levels. CAN members work to achieve this goal through information exchange and the coordinated development of NGO strategy on international, regional, and national climate issues. CAN has regional network hubs that coordinate these efforts around the world.

Climate Change Knowledge Portal (CCKP) was created by the World Bank to serve as a 'one stop shop' for climate-related information, data, and tools, supported by the Global Facility for Disaster

Reduction and Recovery and others. The Portal provides an online tool for access to comprehensive global, regional, and country data related to climate change and development. The successful integration of scientific information in decision making often depends on the use of flexible frameworks, data, and tools that can provide comprehensive information to a wide range of users, allowing them to evaluate how to apply the scientific information to the design of a project or policy.

World Meteorology Organisation World Climate Programme (WCP) primarily aims at enhancing climate services with adequate focus on user interaction, to facilitate evermore useful applications of climate information to derive optimal socio-economic benefits and thereby underpins the Global Framework for Climate Services (GFCS). The scope of WCP is to determine the physical basis of the climate system that would allow increasingly skilful climate predictions and projections, develop operational structures to provide climate services and to develop and maintain an essential global observing system fully capable of meeting the climate information needs.

The Non-State Actor Zone for Climate Action (NAZCA) is an online site developed with the support of the UNFCCC, showcases the extraordinary range of game-changing actions being undertaken by thousands of cities, investors and corporations.

The Global Cites Network (ICLEI) is the world's leading network of more than 1,000 cities, towns and metropolises committed to building a sustainable and climate-resilient future.

United Nations Alliance on Climate Change Education, Training and Public Awareness was launched in 2012 in response to the increasing impact of climate change on development and security issues, a growing number of United Nations organizations work closely with governments to build green and climate-resilient societies.

Climate Technology Centre and Network (CTCN) is the operational arm of the UNFCCC Technology Mechanism, hosted by the UN Environment Programme (UNEP) and the UN Industrial Development Organization (UNIDO). The Centre promotes the accelerated transfer of environmentally sound technologies for low carbon and climate resilient development at the request of developing countries. We provide technology solutions, capacity building and advice on policy, legal and regulatory frameworks tailored to the needs of individual countries.

REDD+ web platform, mandated by the UNFCCC COP in decision 2/CP.13, was established with the purpose of making available such information on the outcomes of activities relating to REDD+, including activities on capacity building, demonstration activities, addressing drivers of deforestation and mobilization of resources.

The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (**UN-REDD)** was launched in 2008 and builds on the convening role and technical expertise of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP). The UN-REDD Programme supports nationally led REDD+ processes and promotes the informed and meaningful involvement of all stakeholders, including indigenous peoples and other forest-dependent communities, in national and international REDD+ implementation.

The Global Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (PROVIA) is a global initiative which aims to provide direction and coherence at the international level for research on vulnerability, impacts and adaptation (VIA). Launched with the support of leading scientists and decision-makers, PROVIA responds to the urgent call by the scientific community for a more cohesive and coordinated approach, and the critical need to harmonize, mobilize, and communicate the growing knowledge-base on VIA.

weADAPT is an online 'open space' on climate adaptation issues (including the synergies between adaptation and mitigation) which allows practitioners, researchers and policy makers to access credible, high quality information and to share experiences and lessons learnt with the weADAPT community.weADAPT is developed and maintained by the Stockholm Environment Institute (SEI). Content is curated both by SEI and the weADAPT team, a dynamic network of Knowledge Partners, using an innovative suite of technologies.

Global Adaptation Network aims to support the mobilization of existing information and knowledge, provision of targeted and packaged support and advisory services, building capacity for the uptake of knowledge, and linking the supply of expertise and knowledge with the demands. Currently there are three regional networks linked to the GAN that are operational: the Regional Gateway for Technology Transfer and Climate Change Action (REGATTA) in Latin America and the Caribbean, the Asia Pacific

Adaptation Network (APAN), and the West Asia Regional Network on Climate Change (WARN-CC). The Africa Adaptation Knowledge Network is in the process of being established. The Global Adaptation Network forms a light umbrella structure, linking the regional networks and helping them to exchange knowledge, experiences and lessons learned.

The Climate and Development Knowledge Network (CDKN) supports decision-makers in designing and delivering climate compatible development by combining research, advisory services and knowledge management in support of locally owned and managed policy processes. It works in partnership with decision-makers in the public, private and non-governmental sectors nationally, regionally and globally. It is managed by an alliance of organisations led by PricewaterhouseCoopers LLP (PwC), and including Fundación Futuro Latinoamericano, LEAD International, LEAD Pakistan, the Overseas Development Institute, and SouthSouthNorth.

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) addresses the increasing challenge of global warming and declining food security on agricultural practices, policies and measures through a strategic collaboration between CGIAR and Future Earth. Led by the International Center for Tropical Agriculture (CIAT), CCAFS is a collaboration among all 15 CGIAR research centers and coordinates with the other CGIAR research programs. CCAFS brings together some of the world's best researchers in agricultural science, climate science, environmental and social sciences to identify and address the most important interactions, synergies and trade-offs between climate change and agriculture. CGIAR CGIAR is a global research partnership for a food-secure future. Its science is carried out by 15 Research Centers in close collaboration with hundreds of partners across the globe.

The Global Carbon Project (GCP) was established in 2001 in recognition of the large scientific challenges and critical nature of the carbon cycle for Earth's sustainability. The scientific goal of the project is to develop a complete picture of the global carbon cycle, including both its biophysical and human dimensions together with the interactions and feedbacks between them. The Global Carbon Project was formed to assist the international science community to establish a common, mutually agreed knowledge base supporting policy debate and action to slow the rate of increase of greenhouse gases in the atmosphere.

The World Climate Research Programme (WCRP) organization comprises many partners and stakeholders around the world. Each of these partners contributes services, information, solutions and/or funds into the global WCRP enterprise. The overarching objectives of all members of this network are to contribute to improved understanding of the climate system, climate change and the interactions between climate, people and the environment. Scientists affiliated with WCRP produce the climate change and ozone layer projections and predictions that underpin much of the work of the Intergovernmental Panel on Climate Change (IPCC), as well as the Stratospheric Ozone Depletion Scientific Assessments. WCRP participates in many WMO activities. It works closely with National Meteorological and Hydrological Services on the implementation of the Global Framework for Climate Services, in which it is expected to act as the main research component. Together with the World Weather Research Programme, WCRP is developing a "seamless prediction system" to enable a wide range of weather, climate, hydrological and environmental predictions.

Funding

Green Climate Fund (GCF) was established at the UNFCCC COP 16 as an operating entity of the Financial Mechanism of the Convention. The GCF will support projects, programmes, policies and other activities in developing country Parties. The Fund is governed by the GCF Board.

Global Environment Facility (GEF) was entrusted in 2006 as one of the entities with the operation of the Financial Mechanism of the Convention, as well as the Least Developed Countries Fund and the Special Climate Change Fund, administered by the GEF, shall serve the Agreement. The COP provides regular guidance to the GEF, as an entity entrusted with the Financial Mechanism of the Convention, on policies, programme priorities and eligibility criteria for funding.

Adaptation Fund (AF) was established in 2001 to finance concrete adaptation projects and programmes in developing country Parties to the Kyoto Protocol that are particularly vulnerable to the adverse effects of climate change.

BioCarbon Fund was created in 2004, and allocates resources to projects that transform landscapes and directly benefit poor farmers. It was the first carbon fund established in the world to focus on land use. Housed within the Carbon Finance Unit of the World Bank, the BioCarbon Fund is a public-private sector initiative mobilizing financing to help develop projects that sequester or conserve carbon in forest

and agro-ecosystems. It has been a pioneer in this sector, developing the infrastructure needed to pilot transactions and paving the way for the growing land-use carbon market established to date.

The Forest Carbon Partnership Facility is a global partnership of governments, businesses, civil society, and Indigenous Peoples focused on reducing emissions from deforestation and forest degradation, forest carbon stock conservation, the sustainable management of forests, and the enhancement of forest carbon stocks in developing countries (activities commonly referred to as REDD+). The FCPF has two separate but complementary funding mechanisms – the Readiness Fund and the Carbon Fund – to achieve its strategic objectives. Both funds are underpinned by a multi-donor fund of governments and non-governmental entities, including private companies that make a minimum financial contribution of USD 5 million. The World Bank assumes the functions of trustee and secretariat.

The Climate Investment Funds (CIF) is providing 72 developing and middle income countries with urgently needed resources to manage the challenges of climate change and reduce their greenhouse gas emissions. Since 2008, the CIF has been leading efforts to empower transformations in the energy, climate resilience, transport and forestry sectors. Total CIF pledges of USD 8.3 billion are expected to attract an additional USD 58 billion of co-financing for a portfolio of over 300 projects and counting. The International Bank for Reconstruction and Development of the World Bank Group serves as the Trustee for the CIF, and the CIF has broad-based and inclusive governance structure. The two Trust Funds, the Clean Technology Fund (CFT) and the Strategic Climate Fund (SCF), are each governed by a Trust Fund Committee. The SCF further designates Sub-Committees to govern each of its three-targeted programs: the Pilot Program for Climate Resilience (PPCR), the Forest Investment Program (FIP), and the Scaling-Up Renewable Energy in Low Income Countries Program (SREP). Each Trust Fund Committee and Sub-Committee is composed of equal representation from contributor and recipient countries.

International Climate Initiative (IKI) of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) has, since 2008, been financing climate and biodiversity projects in developing and newly industrialising countries, as well as in countries in transition. In the early years of the programme, its financial resources came from the proceeds of auctioning allowances under the emissions trading scheme. To ensure financial continuity, further funds were made available through the Special Energy and Climate Fund. Both funding mechanisms are now part of the Federal Environment Ministry's regular budget. The IKI is a key element of Germany's climate financing and the funding commitments in the framework of the Convention on Biological Diversity. The Initiative places clear emphasis on climate change mitigation, adaption to the impacts of climate change and the protection of biological diversity. These efforts provide various co-benefits, particularly the improvement of living conditions in partner countries.

Norway's International Climate and Forest Initiative (NICFI) supports the development of the REDD+ international agenda and architecture. The ICFI's primary goal is to help establish a global, binding, long-term post-2012 regime that will ensure the necessary and sufficient cuts in global greenhouse gas emissions to limit global temperature rises to no more than 2°C. Up to NOK 3 billion (USD 517 million) per year has been pledged to the NICFI. The NICFI contributes to several multilateral and bilateral initiatives including the Brazilian Amazon Fund, Congo Basin Forest Fund, Forest Carbon Partnership Facility and Forest Investment Program.

5.2.14 Global Goal 14

Networks

The Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects (Regular Process) was established by the United Nations General Assembly through a series of resolutions. The overall objective, endorsed by the UN General Assembly in UNGA Resolution 64/71 (2009), paragraph 177, is that: "The regular process under the United Nations would be recognized as the global mechanism for reviewing the state of the marine environment, including socioeconomic aspects, on a continual and systematic basis by providing regular assessments at the global and supraregional levels and an integrated view of environmental, economic and social aspects. Such assessments would support informed decision-making and thus contribute to managing in a sustainable manner human activities that affect the oceans and seas, in accordance with international law, including the United Nations Convention on the Law of the Sea and other applicable international instruments and initiatives." The process produced the first **Global Oceans Assessment** in 2016.

The International Seabed Authority (ISA) is an autonomous international organization established under the 1982 United Nations Convention on the Law of the Sea, through which States Parties to the Convention organize and control activities on the seabed and ocean floor in areas beyond the limits of national jurisdiction. It has three active training streams, the Endowment Fund supporting the participation of qualified researchers from developing countries in cooperative research on the seabed; the ISA/Contractors Training programme aimed at training developing countries' scientists and managers and the ISA Internship Programme that, in a twofold approach, receives young scientists and managers from developing countries at ISA headquarters to learn about the goals and functions of ISA, but also receives young, highly qualified personnel to reside and contribute for short periods to ISA activities.

UNESCO-IOC's Nutrients and Coastal Impacts Research Programme focuses on interactions between climate, nutrients, and coastal dynamics, and the challenges and opportunities that resulting ecosystem changes pose for tourism, institutions and governance. Its Harmful Algal Bloom Programme aims to foster the effective management of, and scientific research on, harmful algal blooms in order to understand their causes, predict their occurrences, and mitigate their effects.

UNEP's Regional Seas Coordinating Office and the Global Programme of Action (GPA) have embarked on the development of a 'global initiative on marine litter'. Although marine litter is found in all oceans and sea areas of the world, this proposed initiative would concentrate, among others, on the establishment and development of pilot regional activities in regions that are particularly affected. The global initiative would also provide a global platform for the establishment of partnerships, co-operation and co-ordination of activities for the control and sustainable management of marine litter.

Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), the United Nations mechanism for collaboration and coordination which conducts assessments and in-depth studies to evaluate the state of the marine environment, including socio-economic aspects, and identify emerging issues. The Commission is coordinating the GESAMP Working Group 40 on 'Sources, fate and effects of micro-plastics in the environment'.

The Nereus Program, created in 2011 by the Nippon Foundation and the University of British Columbia, is a global interdisciplinary initiative created to further our knowledge of how best to attain sustainability for the world's oceans. It is a global partnership of six leading marine science institutes with the aim of undertaking research that advances our comprehensive understandings of the global ocean systems across the natural and social sciences, from oceanography and marine ecology to fisheries economics and impacts on coastal communities. Current partners include: the University of Cambridge, Duke University, Princeton University, Stockholm University, United Nations Environment Programme – World Conservation Monitoring Centre and Utrecht University.

FishBase is the largest global species database of fish species (specifically finfish) comprising Comprehensive species data, including taxonomy, biometrics, behaviour, distribution, habitats and photos.

The Global Sustainable Seafood Initiative (GSSI) is a global platform and partnership of seafood companies, NGOs, experts, governmental and intergovernmental organizations working towards more sustainable seafood for everyone.

Regional fishery bodies (RFBs) have a key role in the governance of shared fisheries, most providing advice to their members. R**egional fisheries management organizations (RFMOs)**, an important subset of RFBs, have a mandate and the capacity for their members to adopt binding conservation and management measures based on best scientific evidence.

The Coastal Fisheries Initiative (CFI) aims to support environmentally, economically and socially sustainable use and management of coastal fisheries, complementing the GEF multi-country Large-Marine Ecosystem (LME) approach. The initiative will focus on: Strengthening the fisheries sector's policy, legal and regulatory frameworks to incorporate environmental, social and economic sustainability considerations; Improving the capacity and capability of fishing nations, regional management bodies and empowering communities in sustainable management of fisheries; Promoting private-public partnerships that enable responsible investment along the supply chain, fostering sustainable fisheries and sustainable development.

The Food and Agriculture Organization of the United Nations (FAO) Blue Growth Initiative (BGI) aims at building resilience of coastal communities and restoring the productive potential of fisheries and aquaculture, in order to support food security, poverty alleviation and sustainable

management of living aquatic resources. Promoting international coordination is crucial to strengthen responsible management regimes and practices that can reconcile economic growth and food security with the restoration of the eco-systems they sustain. Launched in 2013 and led by the FAO and its partners – UNDP, NORAD, WWF, UNEP, ICFA, MSC, GEF, World Bank, the Netherlands –, the BGI has been working with 10 developing countries: Cabo Verde, Madagascar, Seychelles, Senegal, Kenya, Mauritania, Morocco, Algeria, Bangladesh, and Indonesia.

"Too big to ignore" is is a research network and knowledge mobilization partnership established to elevate the profile of small-scale fisheries, to argue against their marginalization in national and international policies, and to develop research and governance capacity to address global fisheries challenges.

The Fisheries Transparency Initiative FiTI is a global multi-stakeholder initiative that has the aim of improving transparency and participation in the fisheries sector. It has been developed to complement other initiatives, including most importantly the FAO's Voluntary Guidelines for Securing Small-Scale Fisheries and the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests. Both of these guidelines call on governments to improve information gathering and transparency on small-scale fisheries.

The Global Record of Fishing Vessels Refrigerated Transport Vessels and Supply Vessels (Global Record) is a voluntary, phased and collaborative global initiative of the FAO that intending to make information available on vessel identification and other relevant data with the aim of providing a reliable and rapid way to contrast data with other sources. Fishing vessels are included but also other vessels involved in fishing operations are included. The main objective of the Global Record is to provide a powerful tool to prevent, deter and eradicate the Illegal, Unreported and Unregulated (IUU) fishing activities, making it more difficult for vessels operating outside the law.

The Tara Oceans expedition is a 3 year mission around the world aiming to understand how the nature and diversity of planktonic life will be affected by climate change and acidification. The impacts of plankton on life on earth are so broad that they are highly important for global human security; it is absolutely essential to get a better understanding of plankton ecosystems. The expedition is also collecting data on poorly explored coral reef ecosystems.

The International Ocean Carbon Coordination Project (IOCCP), sponsored by UNESCO-IOC and the Scientific Committee on Oceanic Research (SCOR), is a monitoring and research programme focused on the effect of increasing level CO2 emissions on ocean; including calcifying organisms and coral growth rates.

The Ocean Acidification network is meant to provide a central source of information for ocean scientists on research activities in this area, and co-hosts the main international symposium on this issue, 'The Ocean in a high CO2 World'. Its purpose is to provide an interdisciplinary forum to assess what is known about ocean acidification and priorities for future research every 4 years.

The Ocean Acidification International Coordination Centre (OA-ICC), operated by the International Atomic Energy Agency, is an international coordination platform working to communicate, promote and facilitate global activities on ocean acidification.Focusing on international activities which are not currently funded at national or international levels, its role is to support activities related to global actions on ocean acidification.

International Oceanographic Data and Information Exchange (IODE) of the Intergovernmental Oceanographic Commission (IOC) of UNESCO was established in 1961. Its purpose is to enhance marine research, exploitation and development, by facilitating the exchange of oceanographic data and information between participating Member States, and by meeting the needs of users for data and information products. The **Ocean Biogeographic Information System** is part of the International Oceanographic Data and Information Exchange.

The Global Ocean Observing System (GOOS) is the international observation system that ensures long term sustained ocean observations. Since 1990, IOC has been tasked by the international community to co-ordinate the planning, implementation, and on-going development of GOOS.

Global Partnership on Marine Litter seeks to protect human health and the global environment by the reduction and management of marine litter, through several specific objectives: To reduce the impacts of marine litter worldwide on economies, ecosystem, animal welfare and human health. To enhance international cooperation and coordination through the promotion and implementation of the Honolulu Strategy - a global framework for the prevention and management of marine debris, as well

as the Honolulu Commitment – a multi-stakeholder pledge. To promote knowledge management, information sharing and monitoring of progress on the implementation of the Honolulu Strategy. To promote resource efficiency and economic development through waste prevention (e.g. 4Rs (reduce, re-use, recycle and re-design) and by recovering valuable material and/or energy from waste. To increase awareness on sources of marine litter, their fate and impacts. To assess emerging issues related to the fate and potential influence of marine litter, including (micro) plastics uptake in the food web and associated transfer of pollutants and impacts on the conservation and welfare of marine fauna.

Future Earth Knowledge Action Network on Oceans is currently being established. First steps in developing the Oceans Knowledge-Action Network will be to connect to key players related to ocean sustainability from academic and stakeholder communities, to define the key issues where sustainability research can help support healthy oceans and coastal regions. Agreed societally pressing issues with associated researchable questions will then be prioritised for globally coordinated interdisciplinary research towards co-designed synthesis and knowledge products.

Funding

Calouste Gulbenkian Foundation is a Portuguese private institution of public utility, created in 1956 in accordance with the last will and testament of Calouste Sarkis Gulbenkian. Its statutory aims are in the fields of the Arts, Charity, Education and Science. The Gulbenkian Oceans Initiative (GOI) is a five-year program of the Calouste Gulbenkian Foundation that started in 2013 with a vision of protection, conservation and good management of the oceans and of marine ecosystems. Its main mission is to support the economic valuation of marine ecosystem services. The overall goal of the Gulbenkian Oceans Initiative is to increase public and political understanding of marine ecosystem services as strategic assets for sustainable economic development and for human well-being. For that, it will promote activities in three domains – research, public understanding and policy action.

The David and Lucile Packard Foundation is a private foundation that has four main program areas: conservation and science; population and reproductive health; children, families and communities; and local grantmaking. As of December 2015, its investment portfolio totaled USD 6.7 billion and general program grant awards for 2015 totaled USD 307 million. Oceans is one of the sub-programs of the conservation and science program area.

The Bertarelli Foundation was established in 1998 in memory of Fabio Bertarelli and today is active in those fields that have a historic and current significance to the family. The Foundation is seeking to become a leader in global marine conservation. As well as direct sponsorship of no-take marine reserves, the Foundation has commissioned research to prove just how urgent action on our seas has become. The Foundation sponsors the world's largest marine reserve in the Chagos Islands, in the Indian Ocean and has done so since 2010.

The Gordon and Betty Moore Foundation was established to create positive outcomes for future generations. It is a grantmaking foundation, not an operating foundation. The Foundation proactively chooses its programs, strategies and goals, and then selects the best grantees to do the work, rather than responds to unsolicited proposals. The original areas of interest of the foundation were: environmental conservation, scientific research, higher education and the San Francisco Bay Area. Its Marine Conservation Initiative has provided just under USD 250 million in grants to date.

Khaled bin Sultan Living Oceans Foundation is a non-profit environmental science organization and ocean research foundation established to help preserve, protect and restore the world's oceans and aquatic resources through research, education, and outreach. Its aim is to protect and restore ocean health by providing science-based solutions. The Foundation was established in 2000 by His Royal Highness Prince Khaled bin Sultan of the Kingdom of Saudi Arabia. Since then, the Foundation has organized many large-scale scientific surveys including the Global Reef Expedition, the world's largest coral reef survey and high-resolution habitat mapping expedition. Based in the United States, its staff work closely with scientists and partners around the world to study the health and resiliency of coral reefs.

The Nippon Foundation was established in 1962 as a non-profit philanthropic organization, active in Japan and around the world. Initially our efforts focused largely on the maritime and shipping fields, but since then the range of activities has expanded to education, social welfare, public health, and other fields—carried out in more than 100 countries to date. The Nippon Foundation draws the funds needed to support its many projects from the proceeds of Japanese motorboat racing. Under this unique system, the majority of the funds taken in by motorboat racing is returned to bettors as winnings. However, a small percentage is earmarked for philanthropic purposes. Though the percentage that passes through

the Foundation is small, the amount generated is remarkable, averaging approximately 25 billion yen for the past several years.

Oak Foundation was formally established in 1983. It commits its resources to address issues of global, social and environmental concern, particularly those that have a major impact on the lives of the disadvantaged. Today, the Foundation comprises a group of philanthropic organisations based in various countries around the world. Since its establishment, Oak Foundation has made more than 3,600 grants to not-for-profit organisations across the globe. In its Environment Programme, it hopes for more socially and environmentally sustainable societies, for the protection of endangered species and for the transformation of how oceans are perceived and exploited. Its grant-making focuses on three main areas: climate change mitigation; wildlife conservation; and the conservation of marine resources.

Oceans5 makes direct grants, leverages matching grants, provides in-kind services and shares strategic guidance to support its grantees. It focus on projects and campaigns to constrain overfishing and to establish marine reserves. Oceans 5 is an international funders collaborative comprised of Partners and Members who help identify, assess and approve projects for investment. They also remain engaged in project oversight and implementation. The collaborative is a sponsored project of Rockefeller Philanthropy Advisors, a 501(c)(3) nonprofit organization that manages more than USD 280 million in charitable giving. RPA provides staff support and financial management services for a small fee. Oceans 5 Partners commit USD 1 million annually for a minimum of 3 years. Members provide significant support for individual projects, typically over USD 200,000 annually. Partners serve on the Board of Directors and maintain primary responsibility for guiding projects through the design and approval process. Members participate in all discussions and meetings. As appropriate, Oceans 5 also provides guidance to other philanthropies interested in marine conservation.

Pew Charitable Trusts is driven by the power of knowledge to solve today's most challenging problems. They are an independent nonprofit organization. Established in 1948, today, Pew is a global research and public policy organization, operated as a non-partisan, non-governmental organization dedicated to serving the public. It covers topics of the environment (oceans, energy, land conservation and sciences), as well as communities, governing, Environment, health, families and trends. Pew's ocean work includes efforts to create large marine reserves; end illegal fishing; protect key species such as penguins, sharks, tuna and forage fish; and establish policies that protect, maintain, and restore the health of marine ecosystems.

Prince Albert 2 of Monaco Foundation was established in June 2006 by HSH Prince Albert II of Monaco to address the planet's alarming environmental situation. The Prince Albert II of Monaco Foundation is dedicated to the protection of the environment and the promotion of sustainable development on a global scale. The Foundation supports initiatives of public and private organizations, in the fields of research and studies, technological innovation and socially-aware practices. The Foundation supports projects in three main geographical zones and focuses its efforts focus on three main areas. Its three prioirty areas are (1) The mediterranean basin, due to the geographic position of the Principality of Monaco, (2) the Polar Regions, as privileged indicators of climate change evolutions and (3) Least Developed Countries (as defined by the United Nations official list), such as the countries in Sahelian Africa, which are severely impacted by the effects of climate change, the loss of biodiversity and water shortage.

Waitt Foundation is a grant making organization and has invested over USD 60 million in various ocean conservation initiatives. The Waitt Foundation takes a hands-on, partnership-oriented approach to grantmaking. It funds projects and campaigns aimed at ending overfishing, the creation and expansion of Marine Protected Areas, and raising public awareness about the rapid decline in ocean health. With a particular focus on enduring public private partnerships and conservation finance, its principal goal is often to support governments in achieving their own sustainable fisheries and ocean conservation goals. It makes direct grants to Nongovernmental Organizations, and works closely with our global network of strategic partners to leverage grant funds and key relationships wherever possible.

5.2.15 Global Goal 15

Networks

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) is the intergovernmental body which assesses the state of biodiversity and of the ecosystem services it provides to society, in response to requests from decision makers. The mission of IPBES is to strengthen the science-policy interface for biodiversity and ecosystem services for the conservation and sustainable use of biodiversity, long-term human well-being and sustainable development. IPBES is placed under the auspices of four United Nations entities: UNEP, UNESCO, FAO and UNDP and administered by

UNEP. Its secretariat is hosted by the German government and located on the UN campus, in Bonn, Germany. One thousand scientists from all over the world currently contribute to the work of IPBES on a voluntary basis. They are nominated by their government or an organisation, and selected by the Multidisciplinary Expert Panel. Peer review forms a key component of the work of IPBES to ensure that a range of views is reflected in its work, and that the work is complete to the highest scientific standards.

The **International Union for Conservation of Nature (IUCN)** is a membership Union uniquely composed of both government and civil society organisations including (states and government agencies, NGOs large and small, scientific and academic institutions and business associations). It provides public, private and non-governmental organisations with the knowledge and tools that enable human progress, economic development and nature conservation to take place together. Created in 1948, IUCN has evolved into the world's largest and most diverse environmental network. Its experts are organised into six commissions: **the species survival commission; the world commission on protected areas; world commission on environmental law; the commission on social and economic policy; the commission on ecosystem management; and the commission on education and communication**. The IUCN also hosts a number of specialist groups within each of these commissions.

The Society for Conservation Biology (SCB) is an international professional organization dedicated to promoting the scientific study of the phenomena that affect the maintenance, loss, and restoration of biological diversity. The Society's membership comprises a wide range of people interested in the conservation and study of biological diversity: resource managers, educators, government and private conservation workers, and students make up the more than 5,000 members world-wide.

Society for Ecological Restoration is a non-profit organization comprised of individuals and organizations from around the world who are actively engaged in the repair and recovery of degraded ecosystems utilizing a broad array of experiences, knowledge sets, and cultural perspectives. SER members include program managers, policy makers, natural and social scientists, environmental engineers, urban and regional planners, landscape architects, and community advocates representing the public, private, and non-profit sectors. Founded in 1987, SER now has members and partners in more than 60 nations with chapters and networks serving states, provinces and regions of North America, Europe, Latin America, and Australia. SER is also working actively to expand its presence in Asia and Africa.

Group on Earth Observations (GEO) was established in 2005 and is a voluntary partnership of governments and organizations that envisions "a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations and information." GEO Member governments include 102 nations and the European Commission, and 103 Participating Organizations comprised of international bodies with a mandate in Earth observations. Together, the GEO community is creating a **Global Earth Observation System of Systems (GEOSS)** that will link Earth observation resources world-wide across multiple Societal Benefit Areas - Biodiversity and Ecosystem Sustainability, Disaster Resilience, Energy and Mineral Resources Management, Food Security and Sustainable Agriculture, Infrastructure & Transportation Management, Public Health Surveillance, Sustainable Urban Development, Water Resources Management - and make those resources available for better informed decision-making. **The Group on Earth Observations Biodiversity Observation Network (GEO-BON)** is part of GEO, and is a global biodiversity observation network that contributes to effective management policies for the world's biodiversity and ecosystem services.

REDD+ web platform mandated by the UNFCCC COP in decision 2/CP.13, was established with the purpose of making available such information on the outcomes of activities relating to REDD+, including activities on capacity building, demonstration activities, addressing drivers of deforestation and mobilization of resources.

The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (**UN-REDD)** was launched in 2008 and builds on the convening role and technical expertise of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP). The UN-REDD Programme supports nationally led REDD+ processes and promotes the informed and meaningful involvement of all stakeholders, including indigenous peoples and other forest-dependent communities, in national and international REDD+ implementation.

Poverty Environment Network (PEN) is an international research project and network. PEN was a six-year project (2004-2010), and now constitutes the largest and most comprehensive global analysis

of tropical forests and poverty. The core of PEN is the tropics-wide collection of uniform socio-economic and environmental data at household and village levels by about 30 PEN partners (mainly PhD students), which generated a global database with some 5-6,000 households and 200-250 villages from more than 20 countries. The study aimed to put forests more firmly onto the poverty agenda by informing and influencing mainstream forest policy formulation and implementation. PEN was coordinated by CIFOR, and received a major grant from DFID (UK) to support the post-data collection phase (2007-2010) of data analysis, synthesis and dissemination of results. Several PEN partners received fieldwork support from the International Foundation of Science (IFS). Other major donors included the ESRC (UK), DANIDA, USAID and BASIS.

Global Land Project (GLP) is an interdisciplinary community of science and practice fostering the study of land systems and the co-design of solutions for global sustainability. GLP is a network of scientists, institutions and stakeholders engaged in building and enhancing scientific capacity through identifying core questions, synthesizing research and setting future agendas, creating synergies among researchers and stakeholders, and bridging science and decision making. GLP engages with a wide variety of international programmes, networks, and stakeholders in land related activities.

The Global Mountain Biodiversity Assessment (GMBA) is a platform for international and cross-disciplinary collaboration on the assessment, conservation, and sustainable use of mountain biodiversity. It aims to: coordinate and promote scientific research on current and future change in mountain biodiversity and in the provisioning of ecosystem services by mountain regions, facilitate the access to and usage of research outcomes for scientists, policy makers, and stakeholders, and provide a framework for bottom-up involvement of policy makers and stakeholders in research efforts via tools such as co-design and participatory modelling

The Program on Ecosystem Change and Society (PECS), is a Future Earth core-project (jointly sponsored by ICSU and UNESCO). PECS aims to integrate research on the stewardship of social–ecological systems, the services they generate, and the relationships among natural capital, human well-being, livelihoods, inequality and poverty. PECS research will be explicitly transdisciplinary and intersectoral, and will thereby break down barriers that have impeded understanding of social-ecological transformations. PECS aims to understand interactions across scales, such as fast and slow drivers of social and ecological change, thresholds, traps and time lags, in order to identify appropriate operational scales. A comparative, place-based approach, international in scope, is at the core of PECS research.

bioDISCOVERY is a Future Earth core-project that aims to promote the improvement of biodiversity assessments across spatial and temporal scales, different levels of biological organisation, and attributes, processes and functions of biodiversity.

The Bio-Bridge Initiative (BBI) is a new programme focused on catalyzing and facilitating technical and scientific cooperation among Parties to the Convention on Biological Diversity and to its Protocols on biosafety (Cartagena Protocol) and on access and benefit-sharing (Nagoya Protocol) by: linking Parties that have specific technical and scientific needs with Parties or institutions that are able to provide the necessary technical support and resources to meet those needs through mutual partnerships; and creating the space for countries and institutions to share knowledge, good practices and lessons learned with each other.

The PoWPA Friends Consortium is an informal collaboration of individuals, non-governmental organizations, UN organizations and governments, united by the common theme of supporting implementation of the Programme of Work on Protected Areas. This consortium has assisted in conducting dozens of regional training workshops on aspects ranging from ecological gap assessments, business planning, sustainable finance, management effectiveness and capacity.

Funding

The Global Environment Facility (GEF), established on the eve of the 1992 Rio Earth Summit, is a catalyst for action on the environment – and much more. Through its strategic investments, the GEF works with partners to tackle the planet's biggest environmental issues. The GEF is a partnership of 18 agencies including United Nations agencies, multilateral development banks, national entities and international NGOs, working with 183 countries. The GEF has a large network of civil society organizations, works closely with the private sector around the world, and receives continuous inputs from an independent evaluation office and a world-class scientific panel. It is a financial mechanism for 5 major international environmental conventions: the Minamata Convention on Mercury, the Stockholm Convention on Persistent Organic Pollutants (POPs), the United Nations Convention on Biological

Diversity (UNCBD), the United Nations Convention to Combat Desertification (UNCCD) and the United Nations Framework Convention on Climate Change (UNFCCC).

The Arcus Foundation is a leading global foundation dedicated to the idea that people can live in harmony with one another and the natural world. Arcus Foundation grantees work in more than 30 countries around the world, and affect millions of lives. In 2014, 48 grants totaling more than USD 10 million were awarded to organizations working to protect the great apes, and 178 grants totaling more than USD 18 million were awarded to organizations working to advance social justice for LGBT people around the world. The Arcus Foundation Board of Directors and staff are a diverse group, based in New York, US and Cambridge, UK, working globally to support their partners.

The Gordon and Betty Moore Foundation was established to create positive outcomes for future generations. It is a grantmaking foundation, not an operating foundation. The Foundation proactively chooses its programs, strategies and goals, and then selects the best grantees to do the work, rather than responds to unsolicited proposals. The Foundation selects and coordinates with individuals and organizations that have good ideas and the ability to execute, and funds them to accomplish the job. The original areas of interest of the foundation were: environmental conservation, scientific research, higher education and the San Francisco Bay Area. The foundation manages more than USD 6 billion in assets. Each year, it intends to pay out approximately five percent of the endowment, which in 2016 equates to an annual grant budget of roughly USD 315 million.

The David and Lucile Packard Foundation is a private foundation that has four main program areas: conservation and science; population and reproductive health; children, families and communities; and local grantmaking. As of December 2015, its investment portfolio totaled USD 6.7 billion and general program grant awards for 2015 totaled USD 307 million.

Horizon 2020 is the biggest EU Research and Innovation programme ever with nearly €80 billion of funding available over 7 years (2014 to 2020). Horizon 2020 is the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness. Its emphasis is on excellent science, industrial leadership and tackling societal challenges. The goal is to ensure Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together in delivering innovation. Funding opportunities under Horizon 2020 are set out in multiannual work programmes, which cover the large majority of support available. The work programmes are prepared by the European Commission within the framework provided by the Horizon 2020 legislation and through a strategic programming process integrating EU policy objectives in the priority setting.

The Council for Scientific and Industrial Research (CSIR) in South Africa is one of the leading scientific and technology research, development and implementation organisations in Africa. Constituted by an Act of Parliament in 1945 as a science council, the CSIR undertakes directed and multidisciplinary research, technological innovation as well as industrial and scientific development to improve the quality of life of the country's people. The CSIR is committed to supporting innovation in South Africa to improve national competitiveness in the global economy. Science and technology services and solutions are provided in support of various stakeholders, and opportunities are identified where new technologies can be further developed and exploited in the private and public sectors for commercial and social benefit. The CSIR's shareholder is the South African Parliament, held in proxy by the Minister of Science and Technology.

5.2.16 Global Goal 16

International Advisory Council for the Advancement of Justice, Governance and Law for Environmental Sustainability, established in 2012, is tasked with engaging the legal and auditing community worldwide, supporting the development and implementation of environmental law at all levels, and encouraging the further expansion of environmental jurisprudence.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. CITES is an international agreement to which States (countries) adhere voluntarily. States that have agreed to be bound by the Convention ('joined' CITES) are known as Parties. Although CITES is legally binding on the Parties – in other words they have to implement the Convention – it does not take the place of national laws. Rather it provides a framework to be respected by each Party, which has to adopt its own domestic legislation to ensure that CITES is implemented at the national level.

UN Commission on Crime Prevention and Criminal Justice was established by the Economic and Social Council (ECOSOC) resolution 1992/1, upon request of General Assembly (GA) resolution 46/152, as one of its functional commissions. The Commission acts as the principal policymaking body of the United Nations in the field of crime prevention and criminal justice. ECOSOC provided for the CCPCJ's mandates and priorities in resolution 1992/22, which include improving international action to combat national and transnational crime and the efficiency and fairness of criminal justice administration systems. The CCPCJ also offers Member States a forum for exchanging expertise, experience and information in order to develop national and international strategies, and to identify priorities for combating crime.

UNEP's Environmental Cooperation for Peacebuilding Programme aims to assist countries, regional organizations and the UN system to assess and transform potential sources of conflict over natural resources into an opportunity for cooperation and a platform for peacebuilding. Upon request from Member States and UN country teams, the programme identifies areas that may be vulnerable to conflicts over natural resources and offers targeted training, technical advice, neutral facilitation, and impartial analysis aiming to identify cooperative solutions and mechanisms for coordinated management. To achieve this goal, the programme consists of four pillars based on the main communities of practice across the UN system, namely peacebuilding; peacekeeping; environmental diplomacy; and legal protection.

United Nations Office on Drugs and Crime (UNDOC) is a global leader in the fight against illicit drugs and international crime. Established in 1997 through a merger between the United Nations Drug Control Programme and the Centre for International Crime Prevention, UNODC operates in all regions of the world through an extensive network of field offices. UNODC relies on voluntary contributions, mainly from Governments, for 90 per cent of its budget. UNODC is mandated to assist Member States in their struggle against illicit drugs, crime and terrorism.

The United Nations Peacebuilding Fund is currently supporting more than 120 projects in 25 countries by delivering fast, flexible and relevant funding. Since its creation to the end of 2015, PBF has allocated USD 623 million to 33 countries to help prevent (re)lapse into conflict and sustain peace.

United States Institute of Peace In over twenty-five years, the Institute's grant competitions have awarded around 2,200 grants for research, training, education, media and other programs to prevent, manage, and resolve violent conflict and consolidate post-conflict peace, stability and development

Foundation Center and the Peace and Security Funders Group reports that 288 foundations made nearly 2,000 peace-related grants totalling USD 283.2 Million in 2013. This a fraction of the roughly USD 2 billion foundations provided in 2013 focused on human rights.

MacArthur Foundation International Peace and Security Grants, For more than three decades, MacArthur has awarded more than 1,700 grants totalling more than USD 443 million in an effort to broaden and strengthen the field of international peace and security.

Carnegie International Peace and Security Programme awarded 70 grants totalling USD 27.5 million in 2015.

5.2.17 Global Goal 17

Future Earth is a major international research platform providing the knowledge and support to accelerate transformations to a sustainable world.Launched in 2015, Future Earth is a 10-year initiative to advance Global Sustainability Science, build capacity in this rapidly expanding area of research and provide an international research agenda to guide natural and social scientists working around the world. But it is also a platform for international engagement to ensure that knowledge is generated in partnership with society and users of science.

Future Earth Transformations Knowledge-Action Network is connecting researchers and practitioners all over the world in a concerted effort to identify and fill the knowledge gaps pertaining to societal transformations to sustainability. The Network is based on a conception of "transformation" as a profound and complex socio-ecological process with both short- and long-term implications for the sustainability of natural and social systems. It will operate through a regular programme of events and activities, both virtual and physical, and welcomes ideas for related activities and resources from participants and contributors.

Future Earth Knowledge-Action Network on Sustainable Development Goals aims to bring the scientific knowledge and processes of the Future Earth community into the efforts to implement and achieve the Global Goals. The methodological thinking underpinning this KAN is that of integrated,

system-based, solution-oriented and multi-scale (local to global) approaches. The aim is to ensure that science is both a tool and an approach to achieve the Global Goals, particularly by adopting a cross-cutting approach and addressing key knowledge gaps related to implementation. As many different bodies are involved in global initiatives to promote sustainability, it will act as a convening and coordinating platform, bringing together researchers, stakeholders and decision-makers to source solutions to achieve the goals. Together with the Future Earth community, it will work to enhance communication, promote awareness of the Global Goals and the scientific challenges in reaching them, and strengthen the science-policy interface at all levels of governance.

The Partnerships for SDGs online platform provides global engagement for partnerships devoted to supporting the implementation of the Global Goals. It is both a tool to inform all stakeholders about initiatives carried out by multi-stakeholder partnerships in support of the Global Goals, and a tool for linking progress of those initiatives to various follow-up mechanisms of the 2030 Agenda. It includes both partnerships focused on individual Goals and partnerships concerned with multiple Goals.

UNEP SDG Synergies portal is a component of the UNEP live website which aims to highlight the Global Goals and the relationship between the indicators for the Global Goals.